ELECTRICAL ENGINEERING

MARCH 1947

ALEXANDER GRAHAM BELL
BIRTHDAY CENTENNIAL

Alexander Graham Bell—Scientist

F. J. MANN

This month marks the hundredth anniversary of the birth of the inventor of the telephone, who was a charter member of the Institute, one of its original vice-presidents, and its seventh president (1891–92). Among the awards he received were the John Fritz Medal (1907) and the Edison Medal (1914). The story of his life is one of alternate discouragement and success, with his outstanding achievement constantly postponed by the urgent needs of more immediate problems.

ALEXANDER GRAHAM BELL was born 100 years ago, March 3, 1847, in Edinburgh, Scotland. In commemorating the centennial of his birth, he will be eulogized as a philanthropist, a teacher, and as a man who did much to aid the deaf and hard of hearing, as well as the inventor of the telephone. These he was, it is true. But, judging from his own life and writings, he would have preferred to be remembered primarily as a scientist.

By present standards, Bell might not have qualified as a great scientist. It must be remembered, though, that he was born into a world only slowly awakening to the wonders of scientific discovery. Only a few years before his birth, the Morse telegraph (1832), the McCormick reaper (1833), photography (1839), ether used as an anesthetic (1842), and Howe's sewing machine (1845) had come into being. Compared with research on atomic fission and development of radar, these inventions were the results of crude efforts often carried on over relatively long periods of time in attics or small sheds. But, like Bell's invention of the telephone, they had something in common. They were basic accomplishments, the results of creative thought, often of a single mind.

Nothing in history indicates that these achievements, and many others that followed, rose full-blown from flash-of-genius ideas. Each involved its own painstaking effort. Often never recorded, were the heartbreaking stories of failure by those who struggled toward common goals, but lacked the creative spark essential to success. Bell, before he invented the telephone, overcame numerous difficulties. He had his contemporary rivals, who strove for the same objective—to send the human voice over wires. Credit Bell's triumph to a singularly inventive mind if you will, or to a "lucky break" as some thought. It was Bell's belief, as well as that of many of his colleagues, that his success was due to his unique training and lifelong association with the science of speech and acoustics.

FAMILY BACKGROUND

Bell was born into a family preoccupied with the correction and teaching of speech. Bell's grandfather, Alexander Bell (1790–1865), who started life as a shoemaker in Saint Andrews, Scotland, where for generations his ancestors had been shoemakers, forsook this occupation for that of a Shakespearean actor. After he had married and moved to Edinburgh, he abandoned the stage to become an elocutionist and a "corrector of defective utterance." His grandfather, then, was the first in the family to study the mechanism of speech with the object of correcting defects by explaining to his pupils the correct positions of the vocal organs in uttering sounds.

This profession, founded by the grandfather, became a family profession which was carried on by his children and grandchildren. Both of his sons, for example, David Charles Bell (1817–1902) and Melville Bell (1819–1905), were elocutionists and correctors of defective speech. It should be pointed out, though, that neither the grandfather nor his sons could be called mere reciters or practitioners of cures for defects of speech. They studied the anatomy of speech with scientific thoroughness. Among them they are said to have exerted a strong influence on English speech.

Melville Bell, Alexander Graham Bell's father, won a world-wide reputation in his profession. His "Standard Elocutionist" had run through 168 editions by 1893 and it has sold impressively since then. By the end of his life, some 26 of his textbooks and charts on speech and phonetics were in use in schools and colleges.

When Alexander Graham Bell was in his early teens, his father branched off from the profession of teaching into that of inventor. He called his creation "visible speech," a remarkable system of symbols for depicting the actions of the vocal organs in uttering sounds. These symbols could be used in printed form like letters of the alphabet. He claimed that what he had really devised was a universal single alphabet capable of expressing the sounds of all languages and that his letters, instead of being arbitrary characters, were symbolic representations of the organs of speech and their positions in uttering sounds. Visible speech was actually a code of symbols made up of curved and straight lines—resembling short-

F. J. Mann is the managing editor of *Electrical Communication*, New York, N. Y.

Material for this article was compiled from Bell System and other data.

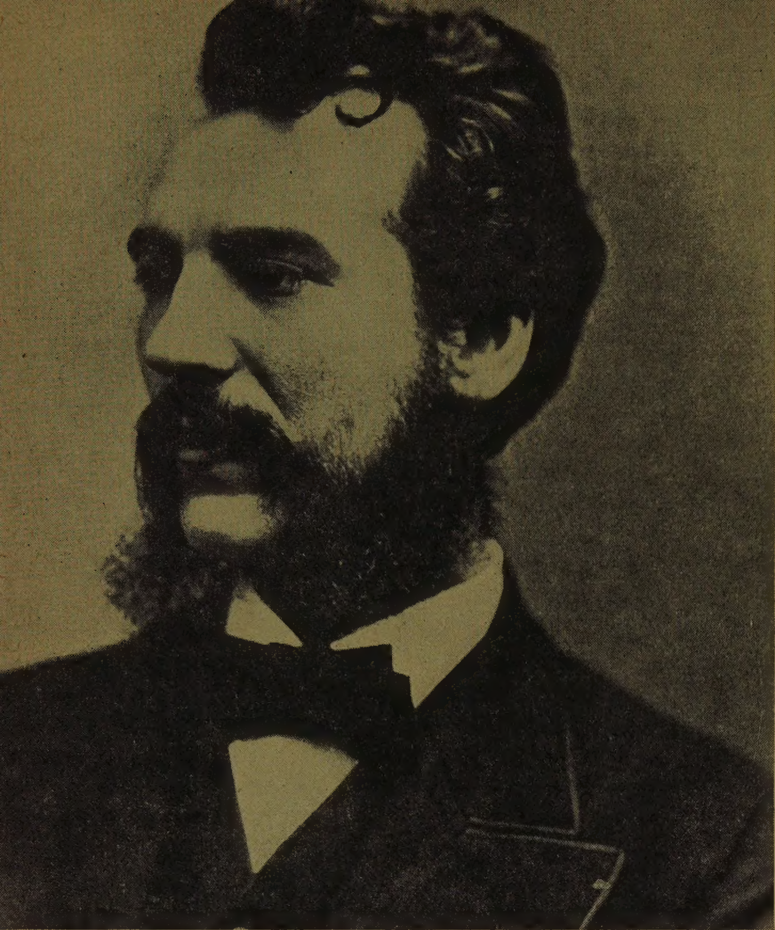


Figure 1. Alexander Graham Bell as he appeared in 1876, the year the telephone patent was granted

hand—that indicated the position and action of the throat, tongue, and lips in pronouncing syllables or various sounds.

Visible speech proved useful as a key to the pronunciation of words in all languages. It also developed that the symbols could be used to guide the deaf in learning to speak. Alexander Graham Bell, as he grew up, became expert in the use of visible speech, particularly in aiding deaf pupils, a fact which had a most important bearing on his life after he came to America.

MUSICAL INCLINATION

Despite this environment of speech correction and scientific investigation, it seemed that young Alexander would follow the arts instead of the family profession. As a boy, Bell exhibited an outstanding aptitude for the piano. "Music especially was my earliest hobby," said Bell. He learned to play at such an early age that, in later life, he was unable to recall a time when he could not play. He seemed to have picked it up by himself without any instruction, and, although he knew nothing of written music, he could play anything he heard and could improvise at length. This acute ear for music was destined one day to pick up the faint "ping" of a reed accidentally plucked in a Boston attic and to recognize in it the possibility of electrical transmission of speech.

Signor Auguste Benoit Bertini, a distinguished professor of music, heard young Bell play and offered to give him instruction in his system of reading music by sight. Bell worked hard at his lessons and became such a promising pupil that Bertini wanted him to become his successor. However, Bertini died before this hope might have been realized. After Bertini's death, Bell received no further formal instruction in music except from his mother who sought to carry out Bertini's ideas as well as she could. But the old professor seems to have inspired young Bell with a passion for music, which led him, for a time, to consider a musical profession. In fact, he did teach music for two years at Weston House, a boy's school in Elgin, Scotland, starting in 1863 when he was only 16 years old.

When we consider today how the same amplifier and loudspeaker reproduce both speech and music, a musical career and the teaching of speech correction are evidently more nearly related than was then apparent. At any rate, Bell's father urged him to give up music as a profession and carry on the family practice in the art and science of speech.

VOCATIONAL HERITAGE

Aleck, as the family called him, had good reason to follow his father's advice. Not only had the father achieved distinction in his profession, but he seems to have been singularly successful in what is often a much more difficult task, that of instilling in his sons a sense of intellectual curiosity and integrity as well as individuality of thought. His influence was exerted in various ways. One was to encourage his boys to make collections of all sorts and to arrange the specimens in accordance with their own ideas rather than in conformity with those of others. Aleck's collection consisted of a large number of skeletons, neatly arranged and classified as in a museum. It included a goodly number of skulls of squirrels, rabbits, cats, and dogs, but the gem of the collection was a real human skull presented to him by his father.

Alexander Graham Bell put great store in this phase of his education. In the last year of his life he wrote:

"I can see in these natural-history collections a preparation for scientific work. The collection of material involved the close observation of the likenesses and differences of objects of very similar kind, and the orderly arrangement, as in a museum, stimulated the formation of generalizations of various kinds . . . I am inclined to think that the making of these collections formed an important part of my education and was responsible for my early bent toward scientific pursuits."[1]

EDUCATION

While Aleck excelled in these exceptional pursuits, he was not considered brilliant at his formal studies. From 1855 to 1859, he attended McLaren's Academy and the Royal High School in Edinburgh, but he lacked enthusiasm for the prescribed subjects and especially disliked Latin and Greek, then considered the mainstays of formal education. His opinion of the advantage of scientific over classical training as a preparation for life was ex-

pressed in his prophetic address to the graduates of McKinley Manual Training School at Washington, D. C., in 1917:

"The nation that fosters science becomes so powerful that other nations must, if only in self-defense, adopt the same plan . . . . Scientific and technical experts are destined in the future to occupy distinguished and honorable positions in all the countries of the world."

It is to his grandfather that a great deal of the credit must go for inspiring and encouraging Aleck to overcome his indifference to formal education. In 1860, when 13, Aleck spent a year with his grandfather in London. His grandfather helped him map out his time and devote certain hours to the ordinary school subjects. He also gave him personal lessons in elocution and English literature. At the same time, Aleck received instruction in the mechanism of speech from his grandfather who permitted the boy to be present at the instruction of some of his pupils so that he might observe the methods of correcting defective utterance.

This year with his grandfather converted Aleck from what he described as "an ignorant and careless boy into a rather studious youth, anxious to improve his educational standing by his own exertions and fit himself for college." The conversion was really from indifference to enthusiasm, for throughout every stage of his development and education, even in later years, his enthusiasm governed his work habits. In fact, in the subjects he loved, like music and science, he was almost too enthusiastic so that for many years he was constantly threatened with breakdowns. However, rather than an overstudious bookish person, he was fun-loving and ardent, so gifted that he took vast pleasure in whatever happened to interest him.

FIRST INVENTION

Bordering on the precocious was an incident Bell often recalled; it led to what he considered to be his first invention and was related by him in 1922:

"When I was quite a little fellow, it so happened that my father had a pupil of about my own age with whom I used to play. He was the son of a Mr. Herdman, who owned large flour mills near Edinburgh, and, of course, I went over to the mills pretty often to play with him there. We romped about and got into all sorts of mischief, until at last one day Mr. Herdman called us into his office for a very serious talk.

" 'Why can't you boys do something useful,' he said, 'instead of always getting into mischief?'

"I mildly asked him to tell us some useful thing to do, and he replied by putting his arm into a bag and pulling out a handful of wheat. He showed us that the grains were covered with husks, and said: 'If you could only take the husks off that wheat, you'd be doing something useful indeed.'

"That made rather an impression upon my mind, and I began to think, 'Why couldn't we take the husks off by brushing the seeds with a nailbrush?'

"We tried the experiment and found it successful, although it involved a good deal of hard work from the two mischief makers. We persevered, however, and soon had a nice little sample of cleaned wheat to show Mr. Herdman. I then remembered that during our explorations at the mills we had come across a large vat or tank with a paddle-wheel arrangement in it that whirled round and round in a casing of quite rough material, brushes of fine wire netting, or something of that sort. If we could only put the wheat into the machine, I thought, the whirling of the paddle should cause the seeds to rub against the rough surface of the casing, and thus brush off the husks.

"It was a proud day for us when we boys marched into Mr. Herdman's office, presented him with our sample of cleaned wheat, and suggested paddling wheat in the dried-out vat.

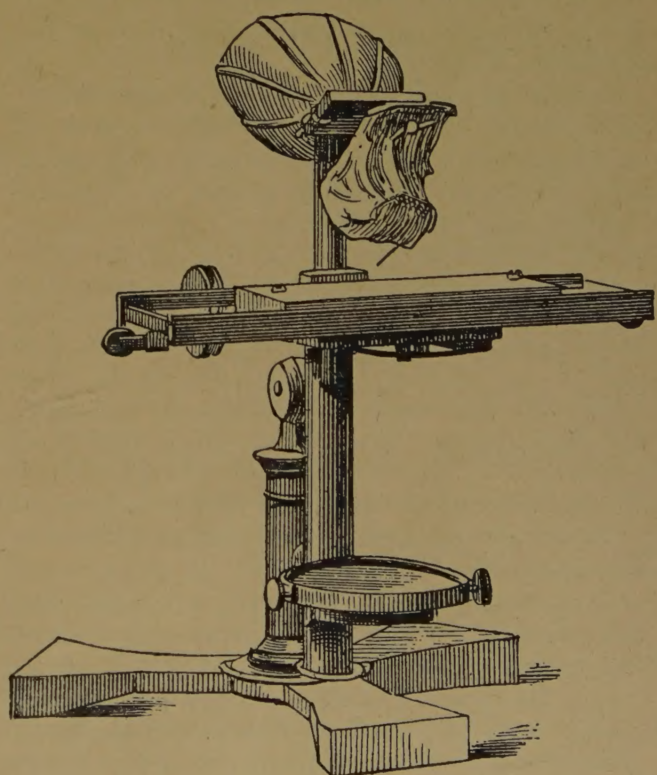
" 'Why,' said Mr. Herdman, "that's quite a good idea,' and he immediately ordered the experiment to be made. It was successful, and the process, I understand, or a substantially similar one, has been carried on at the mills ever since."[2]

EARLY IMPRESSIONS

If this first "invention" had nothing to do with the telephone, later experiments made by Bell when he was 15 years old most certainly did. The father's fame as a scientist of speech problems brought him in contact with some of the most outstanding men of his day. His evident pride in his sons and his interest in their development led him to share these valuable and pleasant associations with them. Thus it was that Aleck, when still a boy, met such men as Alexander J. Ellis, the translator of Helmholtz; Max Muller, Sanskrit scholar; Henry

Figure 2. Drawing of the human-ear phonautograph built by Alexander Graham Bell in 1874

The stylus wrote sound patterns on a plate of smoked glass which was moved across the upper platform. The drawing appeared in the published pamphlet of Bell's lecture on the telephone presented before the Society of Telegraph Engineers, Westminster, England, 1877



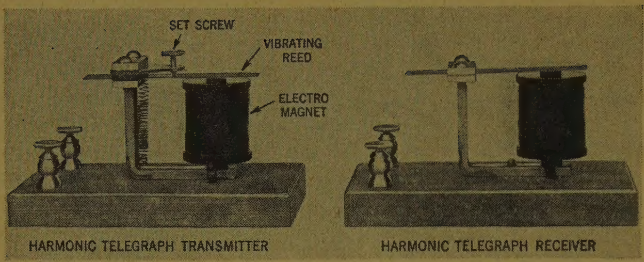


Figure 3. Replicas of the harmonic telegraph instruments used by Bell and Watson in the historic experiments of June 2, 1875

When the transmitter reed vibrated, it was supposed to touch the set-screw contact and send a pulse of current along the line. During the experiments, the reed stuck to the contact and Watson's efforts to free the reed by plucking made the current undulate. Bell, listening to the receiver, placed the free end of the reed against his ear. This made the receiver reed act like a telephone receiver diaphragm. With this arrangement, sound was actually transmitted from the transmitter to the receiver, confirming Bell's carefully worked out theories about the electric transmission of sound

Sweet, phonetician; Doctor Furnival, secretary of the Philological Society of London; Doctor Murray, afterwards Sir James Murray, editor of the great Oxford Dictionary; Prince Lucian Bonaparte, student of Scottish dialects; and Sir Charles Wheatstone.

Each meeting made a vivid impression on Aleck. Probably the one to have the most immediate effect was his first contact with Sir Charles Wheatstone, who had constructed what was then called an automaton speaking machine from a description in a book on the mechanism of the human speech by Baron von Kempelen. Aleck's father took him to visit Sir Charles to see the machine and hear it talk.

Aleck saw Sir Charles manipulate the machine and he heard it speak. Although the articulation was crude, it made a great impression on him. Sir Charles loaned Baron von Kempelen's book to the Bells and Aleck devoured it when he reached home. The book was in French, but he knew the language well enough to be able, with his father's assistance, to read and enjoy it.

EDUCATIONAL TOY

Stimulated by their father, Aleck and his brother, Melville, attempted to construct a speaking machine of their own. They divided up the work, Melville's special part consisting of the larynx and vocal chords, to be operated by the wind chest of a parlor organ, while Aleck undertook the mouth and tongue.

Melville was quite skillful in the use of tools, while Aleck was clumsy with his hands and ineffective where tools were concerned. Aleck hit upon a plan that obviated the disadvantages of this defect in a great degree: he made his models of gutta-percha wherever possible.

The father took an extraordinary interest in the proposed talking-machine and encouraged the boys in every way. Bell stated that it was not until much later in life that he realized that the father looked upon the machine as a valuable educational toy which would compel his sons to become familiar with the operation of the vocal organs. It was for this reason that the father encouraged them to copy Nature itself rather than to follow in the footsteps of von Kempelen and Wheatstone.

The boys attempted to make an exact copy of the vocal organs and work the artificial lips, tongue, and soft palate by means of levers controlled by a keyboard. Aleck started on his part of the work by making a cast from the human skull his father had given him. The mouth parts of the skull were reproduced in gutta-percha. This gave a firm foundation on which to build, consisting of the upper teeth, the upper gum, the hard palate, and the back of the pharynx, with a large hole at the top representing the rear entrance into the nasal cavities. This hole was covered by a valve, consisting of a piece of wood hinged to the palate and covered with a skin of soft rubber stuffed with cotton batting. The operating lever passed through the nasal passages beyond the nose. The lips were formed of a framework of iron wire covered with rubber stuffed with cotton batting, and rubber cheeks were provided which completely closed the mouth cavity.

It was proposed to make the tongue of wooden sections, arranged side by side like the dampers of a piano. Each section was to be elevated by its appropriate lever, and the whole tongue covered by a thin skin of rubber stuffed with cotton batting. This part of the mechanism never actually was completed, but sections of the tongue were made and experimented with.

While Aleck was thus engaged, his brother made an artificial larynx, or throat, of tin, with a flexible tube attached as a windpipe. Inside the larynx were two flat sheets of tin sloping upward toward one another, but not touching at the middle. Stretched tightly upon this structure were two sheets of rubber, the edges of which did touch at the middle.

When the windpipe was blown into, the rubber vocal chords were thrown into vibration, producing a musical sound. By varying the tension of the rubber strips and by changing the force of the breath, it would squeak like a Punch and Judy show, or produce a reed-like musical tone.

When this stage had been reached, the boys were anxious to put the throat and the mouth together to see what the effect would be. Without waiting to complete the tongue, or for the arrival of the organ bellows, they fastened the tin larynx to the gutta-percha mouth and one of them blew through the windpipe. At once the character of the sound was changed; it no longer resembled a reed instrument, but a human voice. Vowel quality also could be reproduced. It could be made to sound as though someone were singing the vowel "ah."

Aleck opened the rubber lips a number of times in

succession while his brother blew through the windpipe. The machine responded by uttering the syllables "ma-ma-ma-ma" quite clearly and distinctly. By using only two syllables and prolonging the second, they obtained good reproduction of the word "mamma," pronounced in the British fashion, with the accent on the second syllable. The next step, of course, was to try the effect on the neighbors.

The house they lived in consisted of a number of flats that opened on a common stairway. They took the apparatus out on the stairway. Melville put the windpipe to his mouth and blew for all he was worth, while Aleck manipulated the lips. The stairway resounded with loud cries of "Mamma! Mamma! Mamma!"—imitating a child in great distress.

Soon a door opened upstairs and the boys heard a woman exclaim, "My goodness, what's the matter with that baby!"

That was all they needed. Delighted with their success, they stole quietly back into their home and gently shut the door.

Although no further work was done on the speaking machine, it had undoubtedly been successful in realizing the father's desire that through it his boys should become familiar with the structure and functions of the various vocal organs.

THE SPEAKING DOG

Aleck was always much interested in his father's examinations of the mouths of his elocutionary pupils. They differed in an extraordinary degree in size and shape, and yet all these variations seemed to be quite consistent with perfect speech. He then began to wonder whether there was anything in the mouth of a dog to prevent it from speaking, and started to make experiments with his intelligent Skye terrier.

Stimulated by rewards of titbits, the dog was soon taught to sit up on his hind legs and growl continuously while Aleck manipulated his mouth, and to stop growling when he took his hands away. Aleck would take the dog's muzzle in his hands and open and close the jaws a number of times in succession. This resulted in the production of the syllables "ma-ma-ma" as in the case of the speaking machine.

The dog's mouth proved too small to enable Aleck to manipulate individual parts of the tongue, but by pushing upward between the bones of the lower jaw, near the throat, he found it possible to close the passageway completely at the back of the mouth. A succession of pushes of this character resulted in the syllables "ga-ga-ga."

The simple growl was an approximation of the vowel "ah" and, followed by a gradual constriction and "rounding" of the labial orifice by the hand, became converted into the diphthong "ow," as in the word "how" (ah-oo). He soon obtained the final element by itself—an imperfect "oo." The dog's repertoire of sounds finally consisted of the vowels "ah" and "oo," the diphthong "ow," and the syllables "ma" and "ga."

Bell then proceeded to manufacture words and sentences composed of these elements, so that the dog could finally say the sentence "Ow-ah-oo-gamama," which, by the exercise of some imagination, readily passed for "How are you, grandmamma."

Of this talking dog, Bell wrote:

"The dog soon learned that his business in life was to growl while my hands were upon his mouth, and to stop growling the moment I took them away, and we both of us became quite expert in the production of the famous sentence, 'How are you, grandmamma?'

"The dog took quite a bread-and-butter interest in the experiments and often used to stand up on his hind legs and try to say this sentence by himself, but without manipulation was never able to do anything more than growl.

"The fame of the dog soon spread among my father's friends, and people came from far and near to witness the performance."[3]

FIRST JOB AS TEACHER

As previously stated, Bell started his teaching career at Weston House in 1863. He actually was rated as a student-teacher, that is, as compensation for teaching, he received advanced instruction at the school. A plan was worked out whereby his brother, Melville, went to the University of Edinburgh while Aleck taught music and elocution and continued his studies. At the end of the year, Bell went to the University for further classical education while Melville taught at Weston House. In 1866, he returned to Weston House as a full-time teacher. In addition, his formal education included a course in anatomy at University College, London, and he matriculated as an undergraduate at London University.

RESEARCH AT WESTON HOUSE

In 1866, while Bell was still at Weston House, an incident occurred that was destined to lead him closer to thinking about the telephone than any of his previous experiments. Recalling his efforts to make a dog talk, and how close he and his brother had come to making a talking machine, it is not surprising that he should have been curious about the sounds produced in his own mouth. Consequently, he carried on a series of experiments to determine the resonant pitches of the mouth cavities during the production of vowel sounds. He would put his mouth and tongue in position to pronounce the vowel and then tap his throat or cheek with his finger or a pencil. Since the two principal cavities are forward and back of the tongue, which moves to help form the sounds, Bell's ear could distinguish the tone of each cavity in the resonant sound that resulted from tapping in various ways. The experiments proved that vowel sounds are compound; that is, they are a combination of resonances from different vocal cavities, and modifications of a single pitch or tone.

At the time Bell believed that these experiments were original. He wrote a long letter to his father explaining

his "discovery about resonance pitches." His father showed the report to Alexander John Ellis, president of the London Philological Society. Ellis told Bell that the same discovery had been made by Hermann L. F. von Helmholtz and described in his classic work, "On the Sensations of Tone as a Physiological Basis for the Theory of Music." Since Helmholtz's book had not then been translated into English (Ellis made the English translation in 1875), Ellis tried to explain the experiment to Bell. Helmholtz, he pointed out, had not only made the same observations, but had gone further. He had built up a synthetic vowel sound from its constituents using three electrically operated tuning forks. One fork represented the pitch of the voice while the other two corresponded in pitch to the front and back cavities of the mouth in uttering a vowel sound.

Bell did not at the time have sufficient electrical knowledge to understand Ellis's description of the apparatus used by Helmholtz. He borrowed a copy of the German text of Helmholtz's book. He knew little German, but he made out just enough from the plates, or thought he could, to confuse the description Ellis had given him and to conclude that Helmholtz had sent the vowel sounds by telegraph. Bell then reasoned that if vowel sounds could be sent by telegraph, why not consonants or even speech?

Bell determined to study electricity, for he felt that it was his duty, as a student of speech, to acquaint himself with the researches of Helmholtz and to repeat Helmholtz's experiments. Consequently, 1867 found Bell, then an instructor in Somersetshire College, Bath, England, experimenting with ordinary telegraph apparatus and vainly striving to use an electromagnet to cause a tuning fork to vibrate continuously.

Three years later he learned from a French translation of the Helmholtz book that the German scientist had not telegraphed the vowel sounds. In the meantime his imagination had been stimulated by the idea. "I thought that Helmholtz had done it," Bell said later, "and that my failure was due only to my ignorance of electricity. It was a very valuable blunder. It gave me confidence. If I had been able to read German in those days, I might never have commenced my experiments!"

TUBERCULOSIS CAUSES MIGRATION TO CANADA

During this period, Bell's two brothers succumbed to tuberculosis, the younger brother, Edward Charles, in 1867 and, in 1870, the elder brother, Melville James.

Alexander Graham Bell also was threatened with tuberculosis. Fearing that his only remaining son might fall a victim, Bell's father resigned his lectureships, disposed of his practice in London, and emigrated to Canada. The family landed at Quebec in August 1870, and soon settled at Tutelo Heights, near Brantford, in Ontario. The change of climate proved beneficial and Bell recovered his health in a few months.

While in Canada, Bell became interested in the dialect of the Mohawk Indians on a nearby reservation. He transcribed many of their words and phrases into visible speech. For this, the grateful Mohawks made Bell an honorary chief of North American tribes. They also taught him the war dance which he often performed thereafter in moments of triumph and which gave a number of Boston landladies some moments of anxiety.

TEACHING AT BOSTON

Bell went to Boston, Mass., in April, 1871, to teach visible speech at the Boston School for the Deaf (now the Horace Mann School). This first assignment was temporary and lasted only two months, but other assignments followed. He became so expert in using visible speech to train deaf children to pronounce properly that in a few weeks he taught them to use more than 400 English syllables, some of which they had failed to learn in two or three years through other teaching methods. Bell's method was to teach the pupil to relate the symbol by touch or demonstration to the vocal process, it indicated. For example, the consonant "P" calls for placing the tongue against the lower teeth, closing the lips, and then opening them to ejaculate a puff of air. After writing the symbols for these processes on a blackboard, Bell would open his own mouth to show the tongue position, then hold the pupil's hand in position to feel the puff of air. Similar procedures were repeated for other letters.

On October 1, 1872, Bell opened his own school of vocal physiology at 35 West Newton Street, Boston, to receive as pupils deaf mutes, persons with defective speech but with normal hearing, and teachers of the deaf and dumb. The following year, he became Professor of Vocal Physiology in the School of Oratory at Boston University. Bell then conducted his classes there, and retained his position on the faculty until 1877.

It was about this time that Bell met two men who were to have a marked influence on his life and the invention of the telephone. The first was Gardiner Greene Hubbard, an attorney inclined toward promotion of civil and governmental progress. The second was Thomas Sanders, a Boston leather merchant.

G. G. HUBBARD

Hubbard's daughter, Mabel, had been left deaf after an attack of scarlet fever when she was four years old. In his efforts to help his daughter, Hubbard was confronted with school authorities who held the opinion that the deaf had no place in normal society—that the best that could be done for them was to send them to an institution where they could be taught the sign language.

Hubbard, however, refused to accept this fate for his daughter and proceeded to do everything possible to save Mabel's power of speech. He even sent her to Germany for instruction in an oral method.

When Bell arrived in Boston with his visible-speech method, Hubbard naturally became his strongest cham-

pion. As a matter of fact, Hubbard had, shortly before, succeeded in having a bill passed in the Massachusetts legislature for the establishment of an oral school for the deaf, over strong opposition based on the premise that any attempt to teach "deaf mutes" to speak "flouted the decrees of Providence." The common interest of the two men in oral-speech training for the deaf resulted in the growth of a strong bond of friendship between them.

Bell was often a welcome guest at the spacious Hubbard home in Cambridge, Mass. During one of these many visits, Bell illustrated some of the mysteries of acoustics with the aid of a piano. "Do you know," he said, "that if I sing the note *G* close to the strings of the piano, that the *G* string will answer me?"

"Well, what then?" asked Hubbard.

"It is a fact of tremendous importance," replied Bell. "It is evidence that we may some day have a musical telegraph which will send as many messages over one wire as there are notes on that piano."

Hubbard could see the value of such a device and later financed Bell's experiments with the harmonic telegraph. Being a practical man of business he could see how such a device might simplify the telegraph business and reduce costs. But he could not, at the same time, see Bell's idea of sending speech over an electric wire as anything but a worthless scientific toy. Such opposition, for a long time, retarded any attempts on the part of Bell to develop a telephone. Nevertheless, Hubbard's legal as well as financial encouragement were invaluable to Bell in filing his patent claims properly, gaining recognition from important persons, and in many other ways.

Not by any means the least important advantage to Bell of Hubbard's friendship was the opportunity to visit at the Hubbard residence. Bell was often invited for Sunday dinner which, at that busy time of his life, was just about the only social recreation and relaxation he had. On these visits he came to know the four Hubbard daughters and, in time, fell in love with Mabel. They were married July 11, 1877.

THOMAS SANDERS

Bell's friendship with Thomas Sanders also started through his work of teaching the deaf to speak. For Sanders had a son, George, who had been born deaf. George Sanders became a private pupil of Bell's when the boy was five years of age. This was in 1872. In 1873, Sanders arranged that George should live with his grandmother, who had a big house in Salem, Mass., and that Bell should board there as the most convenient arrangement to continue George's instruction.

The arrangement included permission for Bell to use the Sanders basement for his electrical experiments, which he now resumed. In addition, he commuted 16 miles to Boston every day, taught at the university, and instructed George Sanders. Although one can well wonder where he found the time, the basement in Salem was soon cluttered with wires, batteries, and tuning forks. Soon, it was overflowing with apparatus and Mrs. Sanders added the entire third floor to Bell's domain.

Even before going to Boston, Bell had conceived the idea of a system of harmonic multiple telegraphy, in which a number of telegraphic signals could be sent simultaneously over the same circuit in either or both directions. This is the plan he had had in mind when he discussed acoustics with Gardiner Hubbard.

SYMPATHETIC VIBRATION EXPERIMENTS

Bell's first experiments were with groups of transmitting and receiving tuning forks so arranged that each fork could vibrate between the poles of an electromagnet. The transmitting forks had connecting wires dipping into small cups of mercury so that current from a battery caused a fork to vibrate in much the same manner as an electric bell. However, each tuning fork vibrated only at its normal pitch and emitted its own characteristic musical tone. A telegraph key was placed in the circuit of each transmitting tuning fork and the group was connected through wires to the receiving forks, placed some distance from the transmitting point.

The transmitting and receiving tuning forks were arranged in pairs, that is, for each transmitter fork there was a receiver fork that vibrated at the same pitch. Each transmitter fork produced a different frequency; and, through the principle of sympathetic vibration or resonance, when the key of one of the transmitting forks was pressed, setting the fork in vibration, the tuning fork tuned to the same frequency at the receiving end also vibrated, the other forks remaining at rest. If two transmitting forks were vibrated, the two corresponding receiving forks responded, and so on. As the forks were all connected over the same pair of wires, such a system would have made it possible to effect a considerable saving in telegraph lines.

While Bell's theory of the harmonic telegraph was sound enough in principle, he never actually succeeded in perfecting it. Practical harmonic telegraph systems were developed by others, notably Elisha Gray. Today somewhat the same principle is employed in carrier telephone and telegraph systems, voice-frequency-operated devices, and, of course, radio transmission on various frequencies to avoid interference with each other is a precise and extended application of resonance or sympathetic vibration.

There could have been many reasons why, hard as he tried, Bell did not succeed with his harmonic telegraph. First, his knowledge of electricity and mechanics was not too great. Then, he had never been particularly adept with the use of his hands. Further, his great interest in acoustics and speech naturally made the problem of "telegraphing speech" more intriguing than an indirect system of communication requiring code characters.

Nevertheless, in 1873 and 1874, Bell persisted in his

attempts to build a practical harmonic telegraph. From tuning forks he turned to tuned vibrating reeds equipped with double electromagnets and, for transmitting, adjustable make-and-break contacts. The receiving vibrator, of course, required no contacts. Actually, these devices were similar to modern high-frequency buzzers. While they proved somewhat better than tuning-fork vibrators, Bell made an even simpler version using only one magnet for each vibrator, but making the reed, and the spacing between reed and magnet, adjustable.

THE DAMPED REED

While experimenting with these instruments, Bell discovered that when the reed vibrated freely it responded to a single pitch. If the transmitted pitch differed only slightly from the pitch to which the receiving reed was adjusted, no signal could be heard. He found, however, that the reeds could be forced to respond to a band of frequencies by damping the free end of the reed. This he accomplished by pressing the reed firmly against his ear while the transmitting instrument was in operation. Then, plucking the reed with his finger, he noted the pitch of the sound produced by its free vibration. If the sound, when the vibrations of the reed were damped, was higher or lower in tone than the normal pitch of the free reed, he raised or lowered the free pitch by shortening or lengthening the vibrating portion of the reed; his object in either case being to bring the free period of the reed into unison with the vibrations of the transmitting instrument. This practice was to have an important bearing on the invention of the telephone.

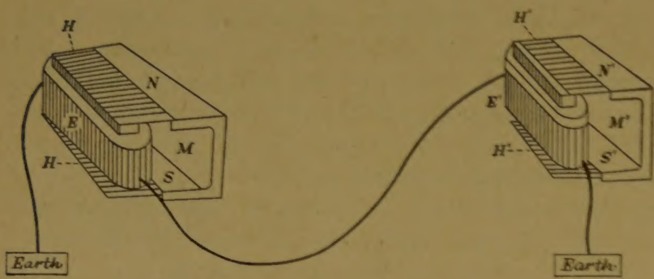


Figure 4. Bell's conception of his harp telegraph apparatus

H—A series of steel reeds, each reed having a different pitch
M—A permanent magnet
E—An elongated electromagnet, placed between the two series of reeds so that the free end of each reed might be close to it without touching it

SINGLE-WIRE HARMONIC TELEGRAPHY

In all of his experiments thus far, Bell had connected his transmitters and receivers directly into the line, using two wires between the transmitting and receiving stations to form a complete circuit. However, telegraph apparatus operated with a single wire and a ground return. The resistance of such a circuit was too high to permit operation of the simple battery circuits Bell was using and, if two wires were required in the harmonic telegraph system, the advantage of such a system would have been greatly reduced. About December, 1873, the idea occurred to Bell of operating his harmonic telegraph by causing the transmitting interrupters each to make and break the primary circuit of an induction coil, the secondary circuit of which could be placed in the main line by depressing a key. This arrangement permitted use of a ground return, but the induction coils introduced a new difficulty. Whereas in the first instance Bell was sending a simple, interrupted direct current between transmitter and receiver, now he was producing a ragged alternating current that the receiver reed could not readily follow.

Bell considered and tried various methods of overcoming this difficulty. It occurred to him that a permanently magnetized reed, if caused to vibrate by mechanical means, could itself occasion electrical impulses of the kind required in the coils of its electromagnet. He planned to set his transmitting reeds in vibration by directing a current of air on them as in the case of organ reeds. But he doubted whether an electric current generated by the vibration of a magnetized reed in front of an electromagnet would be powerful enough to produce at the receiving end of the circuit a vibration sufficiently intense to be practical for use on real lines for multiple-telegraph purposes. So, instead of pursuing the idea further at that time, he devised a rotary circuit breaker to interrupt the current rapidly enough to provide intermittent currents equal in frequency to that of the receiving reed.

STUDY OF SOUND-REPRESENTATION DEVICES

During the winter of 1873–74, while Bell was experimenting with his harmonic telegraph, he also investigated the possibilities of two devices then in use in the physics laboratory at the Massachusetts Institute of Technology. They were the phonautograph and the manometric capsule. Both instruments produced visible patterns from sounds. Bell saw the possibility of utilizing them in his work of teaching speech to deaf children.

The phonautograph consisted of a speaking trumpet closed at one end by a stretched membrane to which was attached a light wooden lever bearing a bristle stylus at its far end. The point of the bristle just touched a plate of smoked glass which could be moved at a uniform rate across it. When the bristle was vibrated by the voice speaking into the trumpet, it traced a shape on the plate that varied with the sound uttered.

The manometric capsule consisted of a cavity in a piece of wood, divided in half by a diaphragm of goldbeater's skin. One side had a gas inlet and the burner connected to it, while the other compartment was connected to a speaking tube. When sound entered the

tube, the air vibrations were communicated through the membrane to the gas and thence to the flame of the lighted burner. The flame, accordingly, followed the sound variations. On viewing the reflection of the flame in a mirror revolving at a suitable speed, the resulting stroboscopic effect showed definite sound patterns. For example, the vowel ē presented the appearance of a long band of light with teeth like a saw. When the sound was changed to ĭ, as in "it", each tooth of the saw became notched. The vowel ĕ, as in "bed", caused the appearance of a pleasing and complicated pattern that resembled lace.

Bell hoped to use one device or the other to photograph wave patterns for his deaf pupils. He felt that, if he could produce a clearly defined pattern of sound, for instance the sound of ē, then the deaf child could practice uttering the sound into a phonautograph or manometric capsule until he could duplicate the pattern with certainty. However, neither device produced useful patterns.

HUMAN EAR PHONAUTOGRAPH

Bell noticed that the phonautograph somewhat resembled the structure of the human ear. Once again returning to nature, as he did when he built the speaking machine, Bell decided to study the human ear mechanism more closely with the idea of constructing a phonautograph more like an ear. He, therefore, discussed the problem with Doctor Clarence J. Blake, a noted Boston ear specialist. Blake suggested that Bell attempt to construct a mechanism from an ear taken from a dead person. Doctor Blake prepared a specimen for Bell who used it successfully in making tracings of sound vibrations on smoked glass.

The human-ear phonautograph never produced patterns suitable for teaching speech to deaf children, but it had two qualities that were directly instrumental in leading Bell's thinking toward the invention of the telephone. First, Bell marvelled at the ability of the tiny ear-drum diaphragm to move the proportionally huge bones of the inner ear, as a result of the vibration of sound waves. The evidence of this motion was translated by the phonautograph into a visible pattern right before his eyes. Further, since the phonautograph was a crude form of oscillograph, he could see that sound waves followed a pattern that was undulatory in character. It has been said that, in relating this point to his knowledge of acoustics, and then further relating it to the undulating pattern electrical currents would have to follow to reproduce sound, Bell hit upon the basic factors that made the electric telephone possible. In the light of present knowledge, where these relationships are commonplace, the importance of Bell's reasoning and discovery might easily be missed. But considered in the light of the historical facts, it has been proved that none of Bell's contemporaries, attempting to produce a talking telegraph, employed the principle of the undulatory current.

Bell's experiments with the human-ear phonautograph were performed during the summer of 1874 while he was at Brantford, Ontario, visiting his father during a vacation period. In the course of that summer, in connection with his work on the harmonic telegraph, his thoughts went back to the idea of mechanically vibrating a polarized reed in front of a magnet. He came to realize that the vibration of the reed would produce on the line wire an undulatory current of electricity corresponding to the undulatory motion of the reed. That is, the direction of polarity of the induced current sent over the line would correspond to the direction of the motion of the reed, being positive when the reed moved in one direction and negative when it moved in the other. Also, the intensity of the current would correspond, from instant to instant, to the velocity of the movement of the

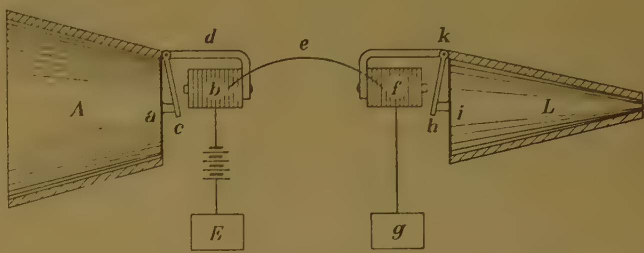


Figure 5. Copy of the drawing of Figure 7 of Bell's patent of the telephone issued March 7, 1876. The transmitter is at the left and the receiver at the right

reed, being greatest when the reed was moving the fastest.

BELL'S THEORY OF SUPERPOSITION

Bell next considered the effect of two or more reeds set into vibration simultaneously. He could see that, when two reeds were in phase, their currents would aid each other, while when they were out of phase the currents might be opposed. He then concluded that "the resultant electrical effect produced upon the line wire by the simultaneous vibration of both reeds would then be expressed by a curve representing the algebraical sum of the two curves considered."[4]

Studying this effect further, Bell saw that a similar result would follow if he had a multitude of reeds of different pitch, each with its own coil, and all the coils connected in one circuit. The thought then occurred to him of having a single electromagnet for all reeds instead of a separate coil for each reed. This line of thought led Bell to the conception of the "harp" apparatus.

In the harp apparatus, identical instruments were to be used at each end of the line and each instrument was to be capable either of transmitting or receiving. Two series of steel reeds, each having a different pitch, and all polarized from a single permanent magnet, were to be placed opposite the pole pieces of a wide electromagnet

so that the free end of each reed would be close to one of the poles of the electromagnet.

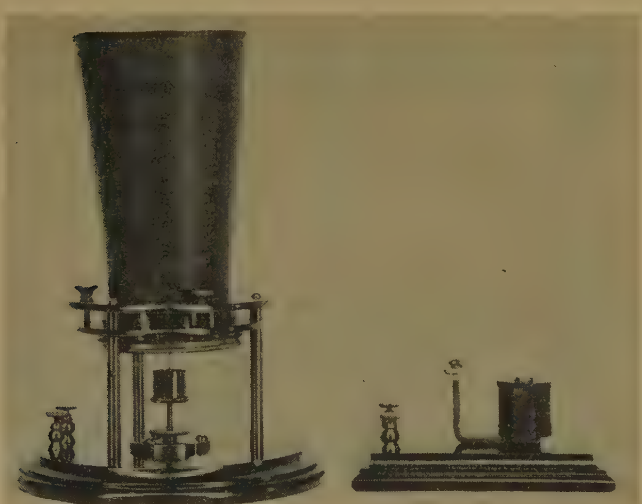
The concept of the harp apparatus brought him back to the phenomenon which he had originally used to illustrate the idea of the harmonic telegraph, the sympathetic vibration of piano strings when notes are sung close to them. In like manner, if a harp had enough reeds, it should pick up every sound of the voice. One could talk into it, and the vibrations would be carried by a complex current to a similar receiver which then would vibrate in such a way that the sounds would be repeated. Bell never built the harp appartus. He felt it would be too complicated to be practical, and, at the time, it would have been too expensive for his limited resources.

Since Bell was not actually attempting to build the harp apparatus that summer in Canada, he was left free to speculate on further refinements. He was aware how the manometric capsule and the phonautograph, employing a single diaphragm, were able to reproduce graphically resultant sound patterns of all vibrations impressed on them, regardless of their complexity. He concluded that a single reed, if it could be made to vibrate like these diaphragms, would generate the same complicated currents as an infinite number of reeds on the harp.

From this line of reasoning came the conception of the membrane speaking telephone. Before he left Brantford, Bell had worked out the plan for such a telephone. His plan was to attach the free end of a reed to the center of a stretched membrane, but instead of firmly fastening the reed to the pole of a permanent magnet, the magnet pole was simply to be brought into close proximity to the hinged end of the reed, so as to polarize it by magnetic induction. The arrangement thus conceived was substantially similar to that subsequently shown as Figure 7 of his United States patent 174,465 of March 7, 1876.

Figure 6. Replicas of the variable-resistance transmitter and reed receiver

It was over equipment such as this that Bell shouted, "Mr. Watson, come here, I want you." This was the first intelligible sentence received over the telephone



While Bell was satisfied that the apparatus he had conceived would produce voice currents, he doubted that strong enough electrical currents would be generated to be heard at the end of a real line. Since experimentation was costly in time and funds, he decided to return to the apparently more practical task of the harmonic telegraph. He did not, therefore, construct the projected telephone when he returned to Boston.

PARTNERSHIP

Although Bell received some income from teaching, it is doubtful if he would have been able to proceed so rapidly with his work if he had not obtained financial help. This aid he began receiving in the fall of 1874 from both Hubbard and Sanders. The two men had separately volunteered to give Bell financial assistance. So Bell, somewhat embarrassed by two such offers, brought them together. At this meeting Hubbard and Sanders agreed to share equally in Bell's expenses, which he put at an extremely modest figure. They also agreed at the time that the shares in any resulting patents would be divided equally three ways.

Bell began by building his own equipment, but, at length, it became clear to him that he lacked both the skill and the time to do this work properly. So he took some of his apparatus to the shop of Charles Williams, Jr., at 109 Court Street, Boston, to be refashioned by an expert electrician. The young man assigned to this work was Thomas A. Watson. Later, Bell asked Watson to leave the Williams shop and come to work for him. They not only became fast friends, but after a time Watson was made the fourth member of the group to share in the patents as part payment for his work.

PATENT APPLICATION

By February 1875, when Bell was only 28 years old, his harmonic telegraph had advanced to the point where he thought patent applications should be filed on it. Consequently, during that month, he put off all pupils and classes and visited Washington, D. C., to draft specifications and file three patent claims. While there he saw Joseph Henry, a great physicist of his day and then secretary of the Smithsonian Institution. Henry saw Bell's hastily set-up telegraph apparatus and Bell talked to the aged scientist about his telephone theory and asked if he should publish it. Henry advised against it, telling Bell that he had the germ of a valuable idea. Bell replied that he feared he lacked the electrical knowledge to work it out. Henry simply said, "Get it!" and encouraged him in other ways. Later Bell wrote, "But for Joseph Henry, I should never have gone on with the telephone."

Bell received a patent on his harmonic-telegraph apparatus a few days after his talk with Henry. While

still in Washington, Bell demonstrated the apparatus to William Orton, president of the Western Union Telegraph Company. Western Union was then the largest corporate body in the United States. Consequently, it was the logical and, perhaps, only customer in this country for any telegraph invention. Moreover, the telegraph company's wires were known to be terribly overloaded with messages and it was generally understood that Western Union would pay as much as a million dollars for a device capable of increasing the number of messages that could be sent over a single line in a given time.

It was natural that a practical business man like Hubbard, under these circumstances, would prefer to see Bell develop the harmonic telegraph rather than the telephone, which was regarded even years after it became a reality as a toy or, at most, a diverting lecture subject. So, despite all of Bell's dreaming about the telephone, the insistence by Hubbard and others that he continue with the harmonic telegraph could not be ignored. Besides Bell, who was greatly in need of funds, saw the possibility of selling the telegraph patents for a large sum which would provide for his experimenting to his heart's content with the telephone.

Figure 8. The first commercial telephone was this wooden-box model, used in 1877

It soon was supplanted by other forms of boxes, then by hand telephones, turned out of wood, that resembled closely the receivers later used on desk telephones

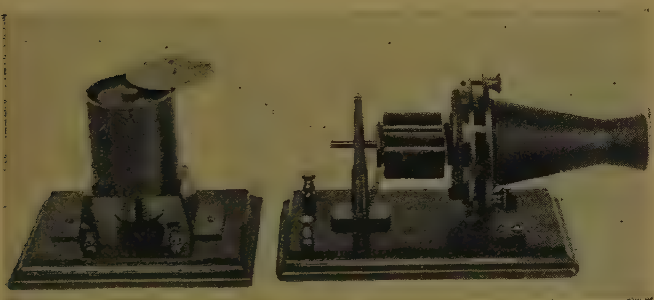


Figure 7. Replicas of the iron-box receiver and an improved magnetic transmitter

The iron-box receiver was developed by Bell shortly after the first intelligible speech was transmitted over the telephone. It employed a metal diaphragm and permanent magnet in a form comparable to the most modern receivers used in telephones today

Bell was heartened when the demonstration before Orton in Washington went well and he received an invitation to bring the harmonic telegraph to Western Union's laboratory in New York, N. Y. He was told by Western Union engineers in New York that the apparatus still had bugs and he received a number of suggestions for making improvements.

When Bell returned to Boston, he had Watson make up three sets of multiple-telegraph apparatus of the make-and-break variety employing tunable reeds. These were set up in the attic of the Williams building, where Bell had obtained the use of two adjoining rooms; a wire line was strung between them.

THE GREAT DISCOVERY

On June 2, 1875, Bell and Watson were ready for a test of this apparatus. Bell, at one end of the line, was tuning up the metal reeds on a group of receivers. Watson, in the adjoining room, was sending the tones of the transmitters to Bell. What followed was probably the most crucial moment in the invention of the telephone. That moment was described by Watson as follows:

"I had charge of the transmitters as usual, setting them squealing one after the other, while Bell was retuning the receiver springs one by one, pressing them against his ear . . . . One of the transmitter springs I was attending to stopped vibrating and I plucked it to start it again. It didn't start and I kept on plucking it, when suddenly I heard a shout from Bell in the next room, and then out he came with a rush, demanding: 'What did you do then? Don't change anything! Let me see?' I showed him. It was very simple."[5]

The make-and-break points of the transmitter spring Watson was trying to start had accidentally been brought into permanent contact, so that when he snapped the spring the circuit had remained closed. Of this, Watson said:

". . . that strip of magnetized steel, by its vibration over the pole of its magnet, was generating that marvelous conception of Bell's—a current of electricity that varied in intensity precisely as the air was varying in density within hearing distance of that spring. That undulatory current had passed through the connecting wire to the distant receiver which, fortunately, was a mechanism that could transform that current back into an extremely faint echo of the sound of the vibrating spring that had generated it, but what was still more fortunate, the right man had that mechanism at his ear during that fleeting moment, and instantly recognized the transcendent importance of that faint sound thus electrically transmitted. The shout I heard and his excited rush into my room were the result of that recognition. The speaking telephone was born at that moment."[5]

Bell, in holding the harmonic receiver tightly against his ear, effectively clamped the free end of the reed or spring, thus damping its natural rate of vibration and causing it, instead, to vibrate in a manner analogous to the diaphragm of the modern telephone receiver. Instead of the customary whine of the intermittent battery current, he had heard an unexpected sound—the twang of a plucked reed—a tone with overtones.

What removes this occurrence from the realm of chance discovery is the fact that Bell, who not only had reasoned that such a current could be generated but foresaw the results it would produce, was probably the one man in the world at that time qualified by training and acuteness of ear to recognize in the faint sound that came to him a confirmation of his theories.

As Bell subsequently wrote about the event in the language of a patent suit deposition:

> "These experiments at once removed the doubt that had been in my mind since the summer of 1874, that magneto-electric currents generated by the vibration of an armature in front of an electromagnet would be too feeble to produce audible effects that could be practically utilized for the purposes of multiple telegraphy and of speech transmission."[6]

Before that history-making day was ended, Bell and Watson had tried and retried the same experiment many times. The next step was to construct the first speaking telephone. Bell gave Watson directions, which followed closely the design of the membrane telephone he had conceived in Brantford the summer before. One of the harmonic receivers was to be mounted in a wooden frame, the free end of its spring to be fastened to a small bit of cork attached to the middle point of a drumhead or diaphragm of tightly stretched parchment also mounted in the wooden frame. There was to be a mouthpiece for concentrating the voice waves on the opposite side of the diaphragm.

THE FIRST TELEPHONE

The next day, June 3, 1875, Watson built the first electric speaking telephone. It had many deficiencies, but before that day was ended enough faults had been corrected so that it could transmit the sound of Bell's voice to Watson. Because the energy generated by the transmitter was weak and the receiver was insensitive, Watson could not hear words, just recognizable voice sounds. Today, however, an exact replica of this first telephone, when connected as the microphone of a public address system, transmits perfectly clear and intelligible speech with a slightly boomy resonance. Connected as a receiver to the output of an amplifier, reproduction is clear enough, but weak and predominant in lower-register frequencies.

Bell and Watson went on experimenting with the telephone all summer. In September, while again at Brantford, Bell started writing the specifications for his first telephone patent. The claims thus written ultimately resulted in his basic United States patent 174,465 granted on March 7, 1876. From the draft, which he wrote and rewrote, resulted the important fifth claim of that patent:

> "The method of, and apparatus for, transmitting vocal or other sound telegraphically, as herein described, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sounds, substantially as set forth."

Bell had spent about five months casting and recasting the patent specifications. During these months he had sought a method of putting a stronger undulating current on the line than was possible with magnetic induction. He had decided this could be done by causing a resistance to fluctuate, so that a current through it would be stronger and weaker as the transmitter diaphragm vibrated. After considering several means of providing such a variable resistance, he decided to use a wire, working like a plunger, up and down in a conducting fluid. So Bell included in his patent specification the description of a transmitter wherein—as the voice made the transmitter vibrate—the wire attached thereto would move up and down in a fluid conductor. As it went deeper, it lessened resistance; as it rose again, the resistance increased. Current passing through the wire and fluid would thus undulate as the sound waves varied.

The winter of 1875–76 was a difficult time for Bell. He wanted to get on with his telephone and develop it to the point where it actually transmitted words. But he felt an obligation to his backers, Hubbard and Sanders, and Hubbard still favored the harmonic telegraph. Unfortunately, in the agreement they had made, Bell had neglected to request funds for himself and now needed money. Consequently, he gave a series of lectures in the fall of 1875. About this time he also completed arrangements with the Honorable George Brown of Toronto, Ontario, and his brother Gordon to pay the expenses of private rooms for housing his electrical apparatus. He felt he needed these rooms because he had heard of strangers visiting the Williams shop and examining his apparatus. With funds provided by the Browns, he engaged two rooms at a boarding house at 5 Exeter Place, Boston, Mass., to which he moved his apparatus in January, 1876.

He then gave up his lectures and devoted his entire time to experimenting. Watson continued to construct his apparatus and assisted in testing it. Bell's zeal at this time has been attributed to his desire to marry Mabel Hubbard. He knew that his professional work, if continued, could yield him a modest income; but he was confident that, if he devoted his attention exclusively to his electrical inventions, they would bring him a fortune—and a fortune was the only thing the modest Bell cared to offer Mabel, daughter of the wealthy Gardiner Greene Hubbard.

The first experiments at the Exeter Place rooms were, strangely enough, not with the telephone, but with the harmonic telegraph which Bell was still trying to perfect

and sell to Western Union. At the time he was working on an electric spark arrester for the contacts of the make-and-break circuits of the transmitters. This was so similar to the variable-resistance transmitter he had described in his patent specification that out of it he developed such a transmitter.

FIRST SUCCESSFUL MESSAGE

It was on March 10, 1876, three days after the telephone patent was granted to Bell, that the first complete and intelligible sentence ever transmitted by telephone was heard. The circumstances were as dramatic as any connected with Bell's previous efforts to transmit speech. Watson had built a variable-resistance transmitter and both Bell and he were planning to spend the night at Exeter Place testing it. Neither of them had any idea that they were about to use the best transmitter yet devised. They diluted the sulphuric acid for its cup, connected it to the battery and to the wire running between the rooms, and then Watson went to the other room to listen.

Almost immediately Watson heard Bell's voice come shouting from the receiving instrument, "Mr. Watson, come here, I want you."

It was a call for assistance. Bell had spilled some battery acid over his clothes as he completed setting up the test transmitter. Since it was only a one-way line, Watson ran to Bell's end of it to shout, "Mr. Bell, I heard every word you said—distinctly." The electric telephone had spoken at last, and so clearly that doubt no longer existed as to its capability of transmitting articulate speech.

IMPROVEMENT OF TELEPHONE

Bell and Watson continued to improve their apparatus and it was about that time that Bell designed the receiver that was to be the forerunner of all telephone receivers. He called it the "iron box" receiver. It employed a metal diaphragm and operated on exactly the same principle as the telephone receiver in use today.

As already described, it had been Bell's habit, while using a tuned-reed receiver, to prevent free vibration of the reed by pressing it closely against his ear. It occurred to him to overcome this difficulty by fettering the free end. At first he proposed clamping both ends of the reed and attaching them to the outer two poles of a W-shaped electromagnet. He soon concluded, though, that a cylindrical iron box with a central core would be better. As he worked it out, the end of the central core became one pole of the tubular magnet thus formed and the rim of the iron box the other pole. By placing a lid or diaphragm on the end of this magnet, he had an armature that was damped all around its periphery and polarized by contact with the rim of the box. The iron-box receiver worked better than any he had used previously. It was this receiver that he demonstrated at the Philadelphia Centennial Exposition in June 1876.

Bell now had apparatus that worked effectively. He had a patent covering the telephone. But he had a long struggle ahead of him. First, he had to prove that the telephone would operate over long stretches of wire. Then, he had to convince the skeptics that the telephone was more than a scientific toy. People generally refused to believe that transmitting the voice over wires was possible. When they actually heard the telephone work, they thought it was accomplished by trickery. At one time, Bell was so discouraged that he offered his patents to Western Union for $100,000. Fortunately for him, Western Union turned him down. It has been said that a few years later Western Union would have been glad to pay 25 million dollars for the Bell patents.

Bell's magnificent speaking voice and his experience as a lecturer served him well during these discouraging years. He gave numerous lectures and demonstrations and actually "sold" the telephone to the public.

OTHER INVENTIONS

These efforts kept Bell from new experiments for several years. Shortly after his return from his honeymoon in England, he began to relinquish to others the task of improving the telephone and developing the necessary associated apparatus. Throughout his life, however, he maintained his interest in scientific matters covering a wide range of subjects.

In 1880, he perfected and patented the photophone, a device for transmitting speech over a beam of light. Bell used the well-known principle that the resistance of crystalline selenium varies with change in light intensity. Little or no practical return came to Bell from his invention. It is interesting to note, however, that this same principle of transmitting speech over light rays was used by both sides for communication purposes during World War II. Also, at present, experiments are under way with a view to using infrared rays, as Bell used them in his photophone, for applications such as the relaying of television programs.

An offshoot of his work with the photophone, Bell called the spectrophone, which he described in a paper before the National Academy of Sciences on April 21, 1881. He had noted in the course of his experiments that many substances, when subjected to an intermittent beam of light, would give off a tone in a telephone receiver. He drew attention to the use of such equipment, particularly, in the detection of invisible rays. As far as is known, nothing came of these experiments.

THE VOLTA LABORATORY

In 1880, Bell received the Volta prize of 50,000 francs from the French government for his invention of the telephone. With the money, he established the Volta Laboratory at Washington, D. C., in collaboration with Sumner Tainter, a maker of optical instruments, and Chichester A. Bell, a cousin who was a specialist in organic chemistry. Each of the three was to work on his own line of pure research. However, when funds be-

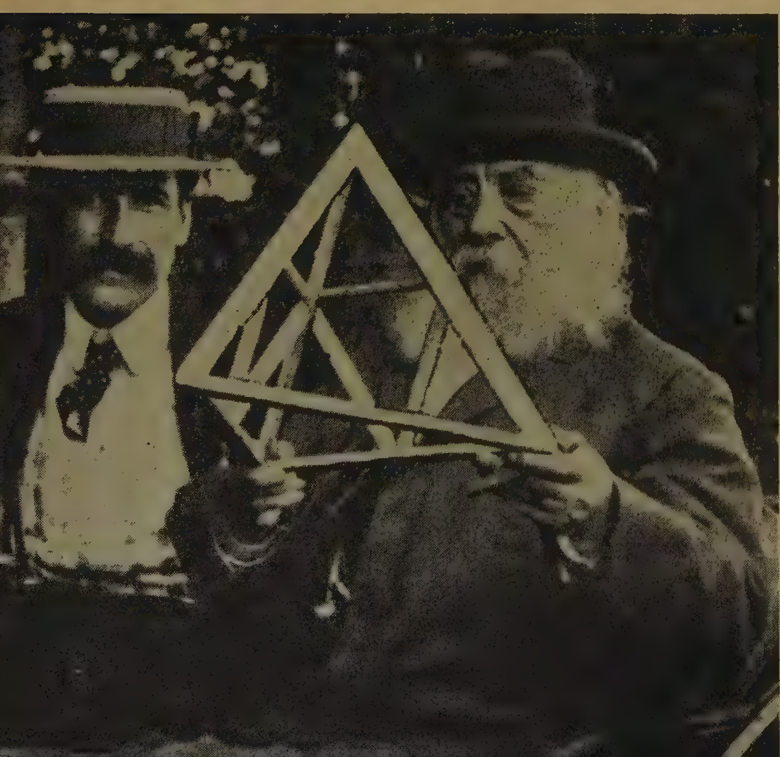
gan to run out, they decided to take up some line of applied science jointly to finance the institution.

They developed an improvement in the making of records for Thomas A. Edison's phonograph which, invented in 1877, was still using metal foil as a recording medium. The Volta group took out the basic patents for phonograph recording on wax cylinders and disks, and sold these to an operating company that launched the recording industry as it is known today. The original idea for using a disk was to permit voice recordings to be mailed conveniently. They were intended as a substitute for written messages, a practice which has begun to come into use only recently.

Bell put his share of the proceeds of the sale of the recording patents into a branch of the laboratory he named the Volta Bureau, set up specifically to carry on his work for the deaf. The bureau at that time was making a statistical study of deafness, particularly of the probability of inherited deafness. The Volta Bureau, still at Washington, continues its work to this day.

When President Garfield was shot in 1881, Bell, who was then living in Washington, hit upon the idea of locating the bullet in Garfield with an induction balance. In the heat of that Washington summer, Bell labored day and night to test the ability of the induction balance to locate metallic masses in the human body. However, Bell's attempts to locate the bullet in the President failed because the doctors in attendance, although trying to comply with Bell's request to remove all metal from Garfield's surroundings, overlooked a steel bedspring directly beneath him. When discovered, further tests were hampered by the fact that Garfield's condition made it difficult to move him. After Garfield's death, Bell perfected an electric probe which was used in surgery for several years and for which he received an honorary degree of doctor of medicine from Heidelburg University in 1886. X-ray technique supplanted the probe about the turn of the century.

Figure 9. Alexander Melville Bell, father of the inventor, examines a cell of one of his son's kites



LATER ACTIVITIES

Although Bell continued scientific research for the rest of his life, it was about this time that he stopped further work on the telephone and other electroacoustic devices. One reason may have been the discouraging round of patent suits he and his associates had to face. Although Bell's right to the telephone patent was upheld by the highest courts, his sensitive nature recoiled from such experiences.

Another explanation is given in a letter written by Mrs. Bell shortly after his death. "I verily believe," she wrote, "that the reason Doctor Bell did not follow up his invention of the photophone—the reason he did not follow that up, and the reason he took up aviation instead was that I could not hear what went on over the radiophone (as the photophone was called later) but that I could see the flying machine."

General John J. Carty, who received this letter, commented as follows:

> "It was a very touching letter and reminds me of what happened on his great day of triumph when Bell talked across the continent to Washington and when he received the congratulations of the Chief Magistrate of our nation. Mrs. Bell was there and Bell, with poignant sadness, looking toward his wife, said to me, 'And to think that she has never heard through the telephone.' "[7]

Bell had great faith in the future of aviation and spent much of his time in research on this subject. All his life Bell had been interested in flight, and his support to aviation was given at a time when to do so risked his scientific reputation. In 1891, he contributed $5,000 for Langley's aviation experiments and on May 6, 1896, saw the successful flight of Langley's steam-driven 16-foot model which, however, did not carry a man.

When, in 1898, Bell was elected a Regent of the Smithsonian Institution, his enthusiasm for Langley's experiments had much to do with obtaining from the War Department an appropriation of $50,000 to be used by Langley for the development of aeronautics.

In 1898, he became president of the National Geographic Society and served in that capacity until 1903. He helped finance the society and was instrumental in building its magazine into a national institution.

Much of Bell's later life was spent at his estate near Baddeck on Cape Breton Island, Nova Scotia. He acquired the estate after a visit there in 1885 and named it Beinn Bhreagh. It was at Beinn Bhreagh that he set up a laboratory and carried on many experiments. While there, he kept a staff of experimenters busy on such diverse ideas as devising a means of condensing fog to furnish fresh water for men adrift at sea, and attempting to breed sheep that would bear more than one lamb at a time.

Besides numerous speeches and papers on subjects re-

Figure 10. Alexander Graham Bell, at extreme right, watches the flight of one of his mulitcell kites, near his summer home at Baddeck, Cape Breton, Nova Scotia, Canada

His kites were an experiment to ascertain the lowest possible takeoff speed for future airplanes

lated to training the deaf to speak and the telephone, Bell wrote articles on the photophone, spectrophone, medical and surgical subjects, eugenics and longevity (based on his studies of the census), his experiments in sheep breeding, aerial locomotion, as well as many general subjects.

The breadth of his interests and the originality of his thinking are indicated in the fact that in 1882 he published "A Proposed Method of Producing Artificial Respiration by Means of a Vacuum Jacket" in which he describes a device anticipating today's iron lung. In 1885, following the collision of a steamer with an iceberg, he wrote advocating a method of determining the location of such an object at sea by detecting a sound echo from it. In a talk in 1906, he advocated measuring the depth of the ocean by echo. Toward the end of his life, he interested himself in the heating and ventilating of houses and, when he had to spend some weeks in Washington, D. C., one hot summer, he air-conditioned his study by directing an electric fan over cakes of ice.

HONORS

Among the honorary degrees conferred on Alexander Graham Bell were: Doctor of Laws: Illinois College, 1881; Harvard College, 1896; Amherst College, 1901; St. Andrew's University, 1902; Edinburgh University, 1906; Queen's University, Canada, 1908; George Washington University, 1913; Dartmouth College, 1914. Doctor of Philosophy: National Deaf-Mute College (now Gallaudet College), 1880; Wurzburg University, 1882. Doctor of Science: Oxford University, 1906. Doctor of Medicine: Heidelberg University, 1886.

In addition to receiving the Volta prize in 1880, he was made an officer of the Legion of Honor by the government of France in 1881.

The medals awarded Bell were: Centennial Exposition, Philadelphia, 1876, gold medal for speaking telephone and gold medal for visible speech. Royal Cornwall Polytechnic Society, 1877, James Watt silver medal for the telephone. Massachusetts Charitable Mechanics Association, 1878, gold medal for the telephone and gold medal for visible speech. Society of Arts, London, 1878, Royal Albert silver medal for his paper on the telephone. République Francaise Exposition Universelle International, Paris, 1878, gold medal for the telephone and a silver medal. Society of Arts, London, 1881, Royal Albert silver medal for his paper on the photophone. The Karl Koenig von Wuertemberg gold medal. Society of Arts, London, 1902, Royal Albert gold medal for his invention of the telephone. John Fritz gold medal, 1907. Franklin Institute of Philadelphia, 1912, Elliott Cresson gold medal for the electrical transmission of speech. David Edward Hughes gold medal and a silver medal, 1913. AIEE, 1914, Thomas Alva Edison gold medal.

Alexander Graham Bell's life ended on August 2, 1922, at Baddeck, Nova Scotia, where his body was laid at rest on the summit of a near-by hill.

REFERENCES

1. Phehistoric Telephone Days, **A. G. Bell.** *The National Geographic Magazine*, Washington, D. C., volume 16, number 3, March 1922. Pages 226–227.

2. Reference 1. Pages 239–241.

3. Reference 1. Page 239.

4. Deposition, Circuit Court of the United States, District of Massachusetts, number 2356A. Printed as the "Red Book" by American Bell Telephone Company, New York, N. Y., 1908. Page 33.

5. The Birth and Babyhood of the Telephone, **Thomas A. Watson.** *Proceedings*, Telephone Pioneers of America, October 17, 1913, page 36.

6. Reference 4. Page 59.

7. Episodes in Early Telephone History, **John J. Carty.** *Bell Telephone Quarterly*, New York, N. Y., volume 5, number 2, April 1926, pages 66–7.

8. The Telephone and Telephone Exchanges—Their Invention and Development (book), **J. E. Kingsbury.** Longmans, Green, and Company, London, England, and New York, N. Y., 1915.

9. Alexander Graham Bell—The Man Who Conquered Space (book), **Catherine Mackenzie.** Houghton Mifflin Company, Boston, Mass., and New York, N. Y., 1928.

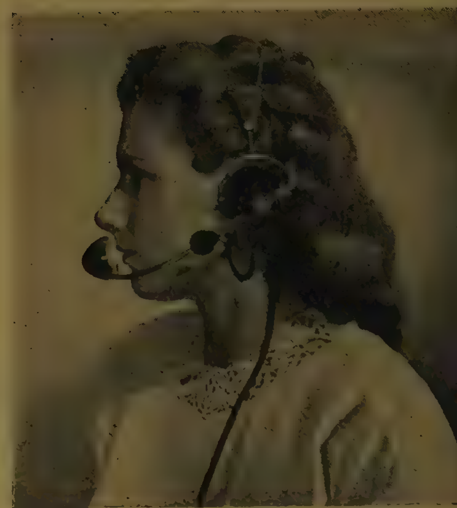
10. Beginnings of Telephony (book), **Frederick L. Rhodes.** Harper and Brothers, New York, N. Y., and London, England, 1929.

11. The Career of Alexander Graham Bell. American Telephone and Telegraph Company, New York, N. Y., 1946.

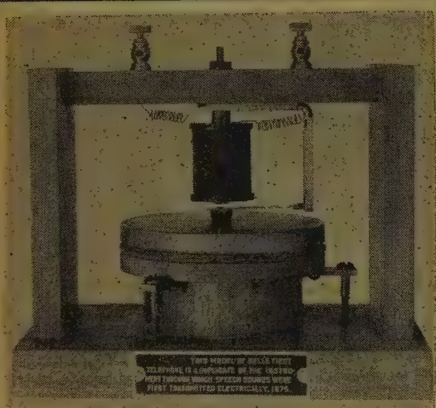
THE GROWTH OF

"The proprietors of the Telephone, the invention of Alexander Graham Bell, for which patents have been issued by the United States and Great Britain, are now prepared to furnish Telephones for the transmission of articulate speech through instruments not more than twenty miles apart. Conversation can be easily carried on after slight practice and with the occasional repetition of a word or sentence. On first listening to the Telephone, though the sound is perfectly audible, the articulation seems to be indistinct; but after a few trials the ear becomes accustomed to the peculiar sound and finds little difficulty in understanding the words."—*from the first advertisement of the telephone.*

Operator of 1880 with a telephone set weighing 6½ pounds



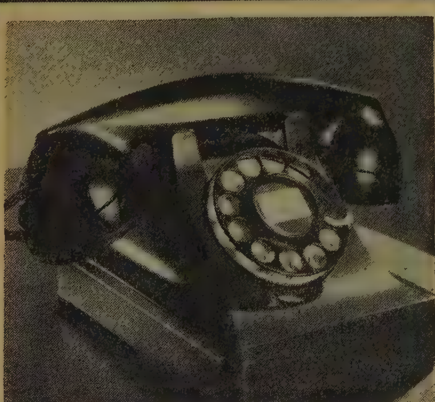
The newest operator's set weighs less than six ounces



Bell's "Gallows Frame" Telephone

Central office in New York in 1880, when only boys served as operators

A telephone switchboard built in 1879



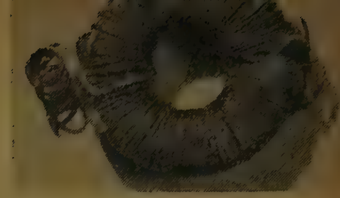
A modern handset telephone

A modern "crossbar" machine-switching telephone exchange

A manual long-distance switchboard typical of those in use today

MR. BELL'S IDEA

1600 1800 2400
30

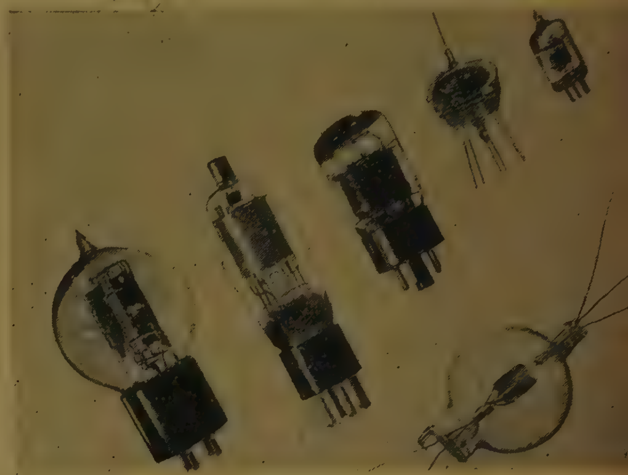


The loading coil, a milestone in telephony

Maze of overhead wires at the corner of Broadway and John Street, New York, in 1890

Nine-tenths of Bell System wires are now in cables

Radio is now an important adjunct to the telephone system



The vacuum tube opened new vistas in telephony

The electric wave filter is fundamental to multiplex (carrier) telephony

This transatlantic exchange symbolizes the expansion of telephone service

How Bell Invented the Telephone

Thomas A. Watson (F '15), who assisted in the development of the telephone and who died December 14, 1934, delivered this address at the annual meeting of the AIEE in New York on May 18, 1915, upon the occasion of the presentation of the Edison Medal to Alexander Graham Bell. The address is given here as it originally was published in AIEE PROCEEDINGS, volume 34, number 8, August 1915, pages 1503–13.

IT is my privilege and pleasure to speak to you of the invention of the telephone, with which event it was my good fortune to be connected, my association with Professor Bell as his mechanical expert having brought me into close touch with nearly all his experiments both before and after his great discovery.

I shall try to tell the story as it impressed itself on my mind in those early days when I was a young man of about 20, just out of my apprenticeship as a maker of electrical apparatus, intensely interested in my work, and with a full share of youthful enthusiasm. In my story, I shall not use the terms and formulas of modern telephony, for they would certainly be out of place in speaking of the time when that science, now so complex, was contained in one human brain.

It was in the year 1875 that the telephone emerged from mists of the unknown into a world that had no dynamos, no electric motors, no trolley cars, no storage batteries, no gas engines, no automobiles, and no professional electrical engineers, for none of our universities had up to that time offered to their students electrical courses.

Those men we all revere—Davy, Faraday, Henry, Volta, Oersted, Ohm, Maxwell, Thomson, and others, had already laid the deep and sure foundations on which modern electrical practise has been built, but apart from the telegraph, electricity, as a practical utility, had scarcely entered the daily life of man.

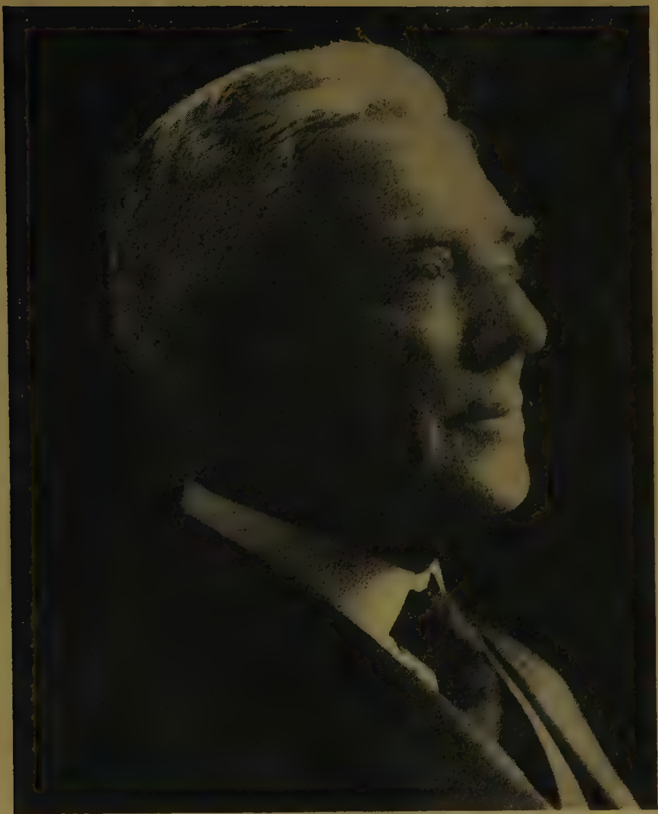
In 1874 in place of the great electrical manufacturing establishments of the present day, there were a few crude little work shops scattered throughout the country, eking out a precarious existence chiefly by making telegraph instruments, school apparatus, call bells, annunciators, etc., and also experimental apparatus for the many inventors who utilized the meagre facilities of those shops to put into practical shape their electrical projects. This was an important feature of the electrical activities of that time, for although the work of these men was for the most part obscure and unfruitful, they were undoubtedly the leaders in the great awakening to the practical possibilities of electricity that began about the time of which I am to speak, and which has since then produced such tremendous results.

In 1874 I was employed as a mechanician in one of the most important of these shops in the United States. It was in Boston, owned and operated by Charles Williams, trained as an apprentice of that famous electric antique, Daniel Davis. Williams, when he was very busy, employed about fifty men, but while I was with him his works seldom ran at more than fifty per cent of their normal capacity. His tools were almost entirely hand lathes. His shop possessed no milling nor screw machine nor had it even a metal planer. Practically all his work was done on hand lathes or with the vise and file. He had on 16-inch engine lathe, to operate which was the highest earthly aspiration of his apprentices. It wasn't in good condition, for one of the boys had run a boring tool into the hole in the spindle so the live center wiggled badly, but we managed to do some rather difficult and accurate work on it in spite of its defects.

Into Williams's dismal and poorly equipped shop Alexander Graham Bell came, in the year 1874, to get his "harmonic telegraph" invention put into practical shape. J. B. Stearns had just then perfected the "duplex telegraph" which would send two messages simultaneously over a single wire. Professor Bell was sure his invention would send at least six or eight. My work at Williams's at that time had become largely making experimental apparatus for inventors and I am glad to say that Professor Bell's work was assigned to me.

Professor Bell was very enthusiastic over the possibilities of his telegraph on which he had been studying ever since his arrival in the United States in 1872. Its operation depended, as you know, on the fact that a stretched string or a tuned reed will be set into vibration when impelled by a succession of impulses corresponding in number per second to its pitch. Here is one of Bell's telegraph receivers. It is a simple electromagnet with a strip of steel clamped to one of its poles, having the other end of the strip free to vibrate over the other pole. The transmitter had the same parts with the addition of contact points that kept its steel reed vibrating when the current was connected and, making and breaking the main circuit at each swing, sent an intermittent current pulsing into the line and through the distant receivers. Each receiver reed was expected to respond to impulses of its own pitch and to ignore those of any other pitch.

I made Professor Bell six or eight of these transmitters with their reeds tuned to different pitches and the same number of receivers with their reeds tuned to correspond.



Thomas A. Watson about 1920

Their test, however, gave results sadly out of accord with his expectations and a long series of experiments followed with rather unsatisfactory results.

The saying so frequently offered for our consolation: that we profit more from our adversities than we do from our successes, was certainly applicable to Professor Bell's case at this time, for had the rhythmic intermittent current that actuated his telegraph accomplished the result he expected and brought him fame and fortune, he might not have been impelled to seek a better form of an electric vibration and so might have missed the discovery that has since placed his name among the immortals.

Professor Bell's experiments with the apparatus I made for him soon revealed the serious defects of the intermittent current wave. He was able to transmit with it two or three messages, each on a different pitch, with a reasonable degree of certainty, but when a greater number was attempted, the added series of impulses seemed to fill the gaps in the other series and produce practically a continuous current, causing serious interference between the messages. The need of a better form of an electric wave was apparent; making and breaking the circuit so many times a second seemed but the first step in the development of his idea. The fact is, Bell had had for a year or more a clear conception of the sort of current he needed, one undulating in waves which would be the exact equivalent of sound vibrations, although he had as yet devised no satisfactory means of producing such a current. An electric current undulating in true wave form would not, he believed, smooth out into a continuous current when several series of impulses were superposed but would keep its wave form through all the complexities that might be impressed upon it. Many sounds can traverse the same air without confusion, so, he thought, such a system of electric waves having the mathematical form of sound waves in the air, might transmit an indefinite number of pitch series on a single wire, to be selected and resolved into separate messages by his tuned receivers.

Bell also foresaw that the apparatus which could generate and transmit such true electric waves might also solve another great problem he had been dreaming about.

One must imagine a world in which the telephone was absolutely unknown to appreciate my feelings when one evening during the course of some experiments on his telegraph apparatus, Bell told me he had an idea by which he believed it would soon be possible to talk by telegraph. He put his conception into the words of his famous formula which I then heard for the first time: "If," he said, "I could make a current of electricity vary in its intensity, precisely as the air varies in density during the production of a sound, I should be able to transmit speech telegraphically." Some practical mechanism to produce such a current was the goal to be striven for, he asserted. He then described to me what he called his "harp telephone," a complex affair having an elongated electromagnet with a multiplicity of steel reeds tuned to many pitches and arranged to vibrate in proximity to its poles; as if the magnets of a hundred of these receivers were fused together side by side. These reeds might be considered as analogous to the rods in the harp of Corti in the human ear. It was Bell's first conception of a speaking telephone. His idea was that a sound uttered near the reeds would cause to vibrate those reeds corresponding to both the fundamental tone and to the overtones of that sound. Each reed would generate in the magnet an electric wave all of which would combine into a resultant complex wave. This passing through a similar instrument at a distant station would, he imagined, set the same reeds into motion and so reproduce the original sound. He had even considered the possibility of using a single reed actuated by a parchment diaphragm over an ordinary electromagnet. He had not had either of his conceptions constructed for he was sure that electric waves generated in this way would be too feeble, to be of the least practical value. His harp telephone, however, was a favorite idea with him and he often spoke of it to me. It was never constructed probably on account of the expense, but with this clear conception in his mind, of the possibilities of a true electric wave, struggling for practical expression, Bell continued his work on his harmonic telegraph trying to attain a result clearly impossible with a transmitter that merely made and broke the circuit.

I am afraid that my attitude towards Bell's telegraph,

after several months' work on it, had become one of disgust with its perversities, and hopelessness as to its future. Its operation was so uncertain and baffling that I remember that even Professor Bell himself began to lose his enthusiasm. His confidence in the intermittent current was vanishing and means for generating his better waves had not arrived. But, "when half gods go, the gods arrive," and this time of depression and disappointment was the right preparation for the new development that was close at hand.

In the attic of the building 109 Court street, Boston, where Williams's shop was, two rooms had been partitioned off and used by Williams for the manufacture of tin foil condensers. These rooms Bell used as his laboratory at that time. Those rough attic rooms, freezing in winter and unbearably hot in the summer, had witnessed many discouraging experiments with the harmonic telegraph with a few slight successes, but on the afternoon of June 2d, 1875, something came to light there that certainly was a recompense for all previous troubles. A slight derangement in the telegraph apparatus gave an opportunity for the great idea that had been incubating in Bell's mind so long to break through its shell.

On that afternoon Bell was in one of the rooms tuning the receivers, an operation they constantly needed. He had a novel way of doing this that he had originated and which had become a habit with him. When he was trying to bring the pitch of a receiver into accord with that of its transmitter, he would press that receiver reed against his ear. He could then hear the nasal drone of the intermittent current coming from the transmitter in the other room and by changing the length of the receiver reed he could adjust its pitch to correspond with that tone. It is interesting to note that when one of his harmonic receivers is used in this way, it becomes a close analogue of a modern telephone receiver, as the edges of the ear clamp the free end of the spring and so damp its natural rate of vibration and cause it to vibrate as a diaphragm.

On the afternoon of June 2d, 1875, Bell was doing this with one of the receivers and at that very moment I happened to snap the steel reed of another instrument in the other room connected into the same circuit, which for some reason was not vibrating as it should, and needed that physical stimulus to start it. It did not start at once so I gave it several vigorous plucks, undoubtedly expressing my opinion of the thing in vivid shop language, when I heard a commotion in the next room and out Bell came in great excitement to see what I had been doing, telling me that he had heard in the receiver at his ear the unmistakable timbre of the sound of one of the reeds. His excitement came from his realization that he had heard the first real sound that had ever been transmitted electrically. It needed but a slight examination of the apparatus to reveal the fact the steel reed I had snapped, magnetized by its long use in connection with magnets, was functioning as a magneto-electric generator and by its vibration had generated in its magnet an electric current that was moulded into undulations exactly analogous to the sound waves of the plucked reed. That such slight means could generate a current not only strong enough to be heard in the receiver but actually to set into visible vibration the reed of another receiver in the same circuit in Bell's room, was a revelation to him. He saw at once that he had been wrong in thinking that the vibration of a steel reed could not produce electric waves of any practical value and that here was the solution, not only of his harmonic telegraph but also of his speaking telephone. He realized immediately that the apparatus that could generate, transmit and receive so efficiently one sound with its fundamental tone and with its overtones could undoubtedly be made to do the same for any sound, even speech itself. The gods had arrived, bringing new enthusiasm and hope; even my gloom was dispelled. We spent the rest of the day repeating the experiment by snapping many different sizes and shapes of steel springs and tuning forks over magnets with the same surprising result and before we parted that night Bell gave me directions for constructing the first speaking telephone. He knew that the diaphragm of the Scott phonautograph when impelled by the vibrations of sound would impress them on the recording style attached to it; why then would not such a diaphragm actuated by the voice, force the steel reed of one of his receivers to follow the vocal vibrations and cause it to generate electric waves with the form of speech waves? Following this thought to its conclusion, Bell sketched out the first speaking telephone the world has ever seen and gave me directions for its construction. I was to mount one of the harmonic receivers in a wooden frame, attach the free end of its spring to the center of a tightly stretched parchment drum head, also mounted in the framework, and provide a mouthpiece to concentrate the voice on the other side of the drum head.

I did this the next day. Here is a replica of it. All that is left of the original is now in the National Museum at Washington. My recollection is that I had this first telephone ready for testing the next day, June 3d. It had many defects. The diaphragm was delicate and easily torn and as it absorbed the moisture of the breath required constant tightening, but it transmitted to my ear over a wire about 200 feet long, running from the fifth story of Williams' building to my work bench on the third story, the unmistakable timbre of Professor Bell's voice in a few imperfect words, using for listening one of the harmonic telegraph receivers through which Bell had made the discovery. It was a meagre result and a bitter disappointment, for I, at least, and, I fancy, Professor Bell too, had anticipated a much greater conversational fluency even in that first telephone.

I have noticed that one's mental attitude towards a phenomenon changes as the novelty wears off. The new effect does not seem so wonderful after a few repetitions.

This is perhaps the reason why my memory tells me that during the months immediately following the discovery that magneto-electric waves generated by a vibrating steel reed were strong enough for practical use, the telephone seemed to grow poorer in its operation instead of better. Bell carried on many experiments for which I made the apparatus, with the purpose of increasing the strength of the new wave not only for its use in his telegraph but also in his telephone. He felt that any improvement applicable to one invention would also help the other. His work for some months was devoted to the telegraph was well as to the telephone, for his friends and financial backers were all strongly of the opinion that it was much wiser for him to devote himself to a real practical thing like the telegraph rather than to such a chimera as the telephone.

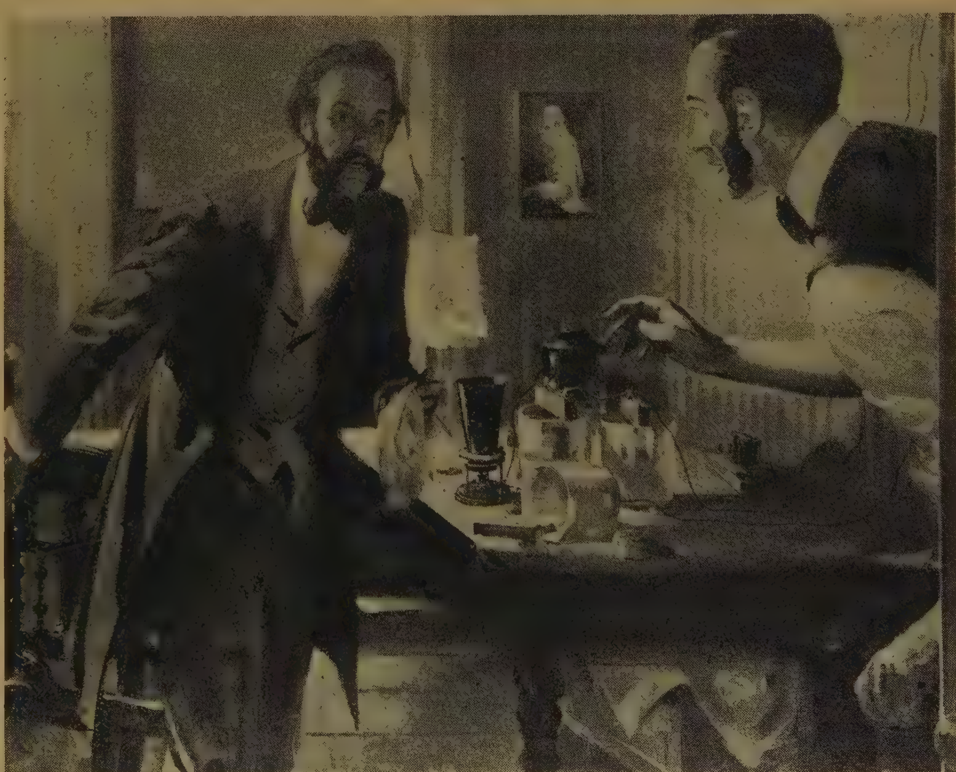
Progress was over the same desert road with a few green spots that inventions seem prone to travel on and it was not until March 10th, 1876, nearly ten months after its birthday that the telephone transmitted its first complete sentence. Though not so noble as the first sentence Morse telegraphed from Washington to Baltimore a few decades before, "What hath God wrought," still the telephone's first sentence had a certain homely practicality about it that clearly takes it out of the category of the frivolous. It was, "Watson, come here, I want you," uttered by Bell from his laboratory to his bed room in the boarding house, number 5, Exeter Place, Boston, I am sure that I went at once. Commonplace as it was, the sentence seemed to break the spell and the telephone progressed after that by leaps and bounds.

I have here the wire over which that first sentence was sent. With a forethought that quite surprises me today, I took down this wire when the laboratory was vacated in 1877, inscribed it and put it into a safe where it remained until a year or two ago when I presented it to the American Telephone and Telegraph Company for its museum. The inscription, which I wrote when I first took it down, is as follows: "This wire connected room 13 with room 15 at number 5 Exeter Place, Boston, and is the wire that was used in all the experiments by which the telephone was developed from the fall of 1875 to the summer of 1877, at which time the telephone had been perfected for practical use. Taken down June 8th, 1877, by Thomas A. Watson."

This was the year of the Centennial Exposition at Philadelphia and Bell decided to make an exhibit there of his inventions. He had me make for him some nicely finished telephones of the best forms that he had devised, including his first battery transmitter.

In June, 1876, Sir William Thomson, chairman of the committee on the electrical exhibits, with members of his committee, examined and tested Bell's apparatus. We have a valuable record of the impression the telephone made upon his mind in his opening address to the British Association, September 14th, 1876, wherein he said:

I heard, "To be or not to be * * * * there's the rub," through an electric telegraph wire; but, scorning monosyllables, the electric articulation rose to higher flights, and gave me messages taken at random from the New York newspapers—"S.S. Cox has arrived" (I failed to make out the S.S. Cox) "The City of New York," "Senator Morton," "The Senate has resolved to print a thousand extra copies;" "The Americans in London have resolved to celebrate the coming 4th of July." All this my own ears heard, spoken to me with unmistakable distinctness by the thin circular disk armature of just such another little electromagnet as this which I hold in my hand. The words were shouted with a clear and loud voice by my colleague judge, Professor Watson, at the far end of the telegraph wire, holding his mouth close to a stretched membrane, such as you see before you here, carrying a little piece of soft iron, which was thus made to perform in the neighborhood of an electromagnet in circuit with the line, motions proportional to the sonorific mo-



An artist's conception of the incident of March 10, 1876, at 5 Exeter Place, Boston

tions of the air. This, the greatest by far of all the marvels of the electric telegraph, is due to a young countryman of our own, Mr. Graham Bell, of Edinburgh, Montreal, and Boston, now becoming a naturalized citizen of the United States. Who can but admire the hardihood of invention which devised such very slight means to realize the mathematical conception that, if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of its current must vary continuously and as nearly as may be in simple proportion to the velocity of a particle of air engaged in constituting the sound?

Up to the summer of 1876 all the tests of the telephone had been made on indoor wires but soon after this convincing trial at Philadelphia, it became evident to Professor Bell that his invention was ready for higher flights. Some preliminary tests on a real line in Brandford, Canada, in which the transmission was all in one direction, the return communication being by telegraph, were followed by a complete test of the telephone's practicability as a transmitter of intelligence between distant points under outdoor conditions. On October 9th, 1876, Bell and I carried on a long conversation over a real telegraph wire about two miles long running from Boston to Cambridge, Mass. Bell was at the Boston end, I, at Cambridge. The telephones we used were those that Bell had exhibited at Philadelphia and were probably the identical instruments with which Sir William Thomson made his famous tests. In order to prove to a doubting world that the telephone could be accurate in its transmission, we made a record of that first conversation ever carried on over a real line and so it has been preserved. At the beginning of the test we were not able to make our voices audible to each other. The cause seemed to be the high resistance of a telegraph relay that I discovered in the circuit in another room in the Cambridge factory, for, after I cut that out, we were able to talk with the greatest ease, as the opening sentences of our recorded conversation indicate, which were:

"Bell: What do you think was the matter with the instruments?

Watson: There was nothing the matter with them.

Bell: I think we were both speaking at the same time.

Watson: Can you understand anything I say?

Bell: Yes, I understand everything you say.

Watson: The reason why you did not hear at first was because there was a relay in the circuit.

Bell: You may be right, but I found the magnet of my telephone touching the membrane.

Watson: I cut this relay out, and then the sounds came perfectly.

Bell: I hear every syllable. Try something in an ordinary conversational voice.

Watson: I am now talking in quite a low tone of voice.

Bell: The sounds are quite as loud as before and twice as distinct"—

and so on for more than an hour. This record which was published in the *Boston Advertiser* of the next day shows a surprising accuracy when the crudeness of those early telephones is taken into consideration.

I need go no further in my account of those days of struggle. The successful working out of the telephone, as in the case with all inventions, was a matter of endlessly considered detail. It was patient, plodding work with a few hours of intense excitement. Other tests were made later in 1876 on still longer lines, and in April, 1877, the first telephone line was constructed 4 miles long, and the telephone installed thereon, beginning its competition with the telegraph as a practical business proposition.

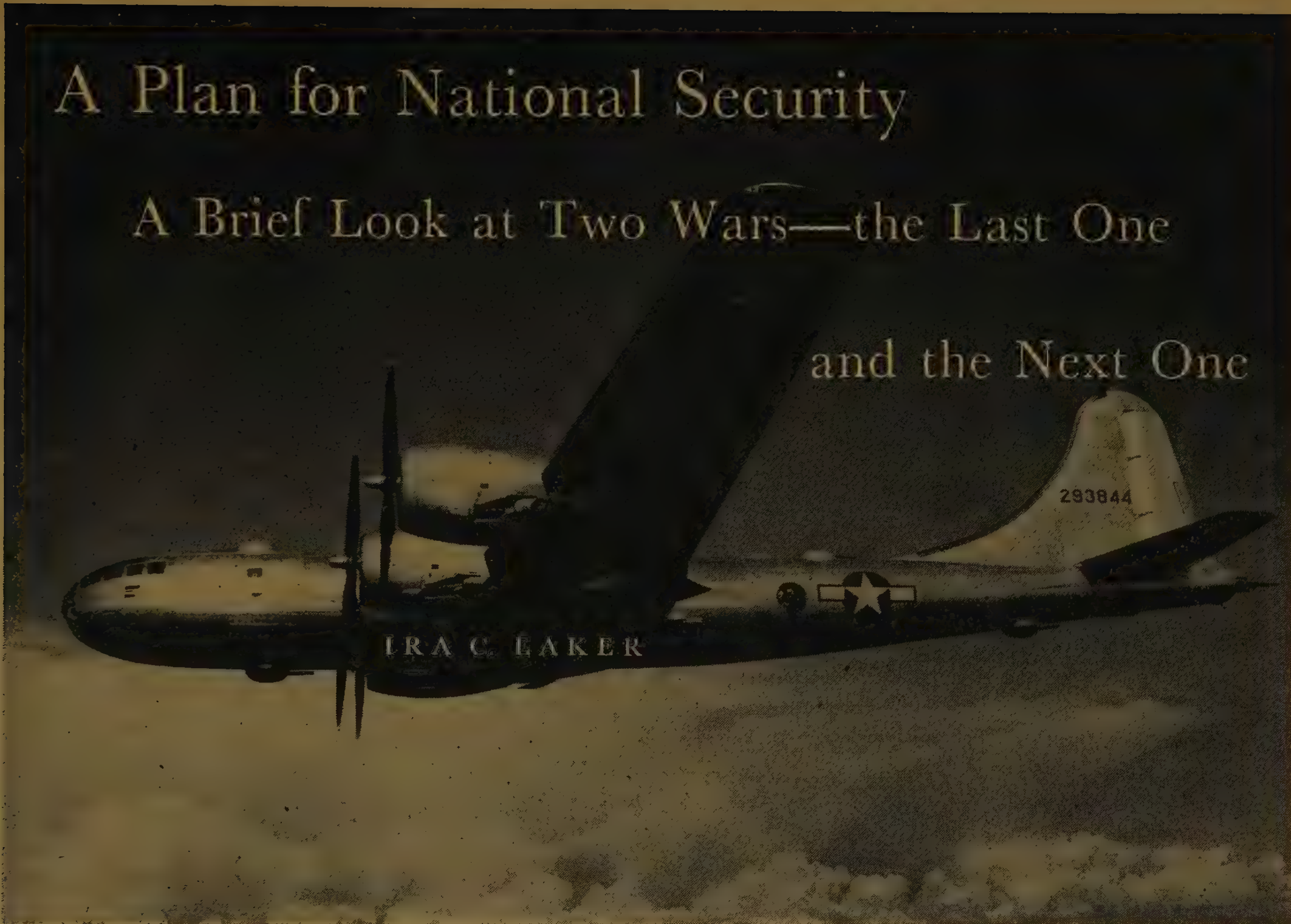
Since then, what tremendous things have been done by the telephone engineers on whom the responsibility has fallen, of continuing the work so splendidly inaugurated by Dr. Bell. The work of these men during the 38 years that has elapsed since Dr. Bell's experiments on the telephone has been ceaseless, energetic, untiring, wise, and accurate in the highest degree. Telephone engineers have overcome one by one the multitude of obstacles that stood in the way of that high ideal—universal service, until today we applaud the latest achievement, under the able leadership of your incoming President- transcontinental telephony, the marvel of which has impressed itself deeply upon my mind all the more because Dr. Bell and I had the honor of formally opening the New York–San Francisco telephone line on January 25th of this year, as we opened the first telephone line, 2 miles long, between Boston and Cambridge, 39 years before. We talked over this line 3400 miles long (really 4400 miles, for its terminus was, during the most of the time, in Jekyl Island, Georgia) more clearly than we talked from Boston to Cambridge 39 years before. Amazing as this was, a climax of the wonders I had been participating in was reached when Dr. Bell switched in another telephone and said to me through it: "Mr. Watson, I am now talking through an exact duplicate of the first telephone made in 1875. Can you hear me?" I heard him perfectly, and when I explained and repeated Dr. Bell's words, I was not surprised to see tears in the eyes of several of those hard-headed business men of California, for I myself was thrilled through and through with the thought of the immensity of the work that had been done since I made that first telephone for Professor Bell and with my realization that this transcontinental line, stupendous achievement as it is, was merely a big incident in the life of the men whose brains have built up an organization almost incomprehensible in its size and scope, with its nine million telephone stations, making twenty-eight million telephone conversations each day over twenty million miles of telephone wires—that stupendous organization we call the "Bell system."

Even these figures are but part of the whole, for there are now in the world more than 14 million telephone stations, making 42 million conversations daily over 33 million miles of wire. We can but wonder at such fructification in four decades of that virile conception of the man we today honor ourselves by honoring—Alexander Graham Bell.

A Plan for National Security

A Brief Look at Two Wars—the Last One and the Next One

IRA C. EAKER



A superiority of man power, raw materials, and industrial capacity, plus the protection afforded by two oceans, have been sufficient to assure to the United States a share in the victory in past overseas wars. However, Lieutenant General Ira C. Eaker warns that warfare of the future practically will eliminate both time and space factors; that, to remain on the winning side, the United States must reorganize its entire defensive structure to provide for the eventuality of sudden attack on home soil.

IT IS a normal American method, as soon as a war is over, for people to dust their hands, turn with relief from war with all its burdens, restrictions, heavy expenditures, and long lists of dead and wounded, and return with all haste to the more cheerful scenes of peacetime living and the brighter prospects of civil occupations and professions.

I am not suggesting any radical change in the American way. It has been adequate for the winning of two great wars during my lifetime. I am suggesting, however, before we close the books of World War II and start the grim business of paying for it, that we have a last look—rake a few dead leaves, as it were—and at least determine the reasons why the Allies won and the enemy lost.

Here is my list of lessons from the war, for whatever it is worth. If it is thought-provoking, I have accomplished my purpose in compiling it.

THE AMERICAN AS A FIGHTING MAN

One great reason for the American share in the victory lay in the fact that the United States had more and better man power.

In the course of the second World War, half a million American airmen served under my command. Nearly 100,000 of those men were listed as missing in action; fully half of them never will return to their homes. Having observed their conduct in battle, I think the least I can do is to tell their parents the kind of fighting men their boys made.

In England, during the early part of the war, when the building of the Eighth Air Force was started with five men, and when the invasion of Hitler's "fortress of Europe" was begun with ten airplanes, one of my worries was how American youth would react to the cruel tests of modern war. I received my answer in those days

Essentially full text of an address before the 20th annual meeting of the American Standards Association, New York, N. Y., November 22, 1946.

Ira C. Eaker, lieutenant general, is deputy commander, United States Army Air Forces, and chief of air staff.

when the Eighth Air Force sometimes was losing ten per cent of its strength on a single mission, when it looked as if its power would be depleted completely in ten days. The following two incidents are typical of those which gave me my answer.

During the Eighth Air Force's infancy a certain young bombardier, because of the skill he had exhibited, was detailed as master bombardier on a mission against German targets. As his airplane approached the target, a German fighter attacked him head-on and fired a 20-millimeter shell into the nose of the airplane. It blew the bombardier to the back of his compartment and tore a large hole in his body. Instinctively, he crawled forward to his bombsight and got off an excellent bombing run, hit the target squarely, as photographs later showed, then fell dead over his bombsight.

This bombardier had a twin brother who was in the same organization. The brother was invited to stay on the ground for a few days because it was felt that the loss of his brother would affect his work. His answer was, "No. I want to carry on as my brother would have me do." The next day he climbed into the bloody cockpit from which his brother was lifted the day before and took off on a mission from which he never returned.

I remember also another instance when, on a difficult mission, a squadron lost all of its airplanes but one. The squadron commander was told that afternoon that it would be some time before new crews and airplanes could be supplied and that his squadron necessarily would be out of the fight during that time. The squadron commander said: "No, sir. We have one airplane left. It came back with 400 bullet holes in it but I have every man in the squadron working on it tonight and it will be ready to go in the morning. We are not out of the fight." In recognition of that squadron commander's spirit airplanes and crews were borrowed from other squadrons and he was back in the fight when a mission was launched the following day.

Since my return from the war theaters, I have noticed that some people have the impression that the Air Forces had an easy time in this war. American Air Forces in Europe lost more than 90,000 men. The Fifteenth Air Force, under my command in Italy, had a combat strength of 20,000. In one year it lost 22,500 men. How many units in World War II lost 114 per cent of their combat strength in a single year?

There are other important reasons for the victory. For example, the United States had greater industrial capacity with which to produce more and better weapons of war. It had time in which to gear its tremendous industrial establishments to full scale stature and production. And the United States had space, a great ocean on either side, which served as protective barriers and prevented American man power and industrial capacity from receiving blows from the enemy while it was being mobilized.

Will these factors be sufficient to place the United States on the winning side should a war come again? First, I wish to emphasize the fact that nobody hopes more fervently than we in the Army that the United Nations may be perfected to prevent any further wars. But until that time comes, armies, navies, and air forces must be provided in sufficient force to insure that the United States will be protected while international peace machinery is being developed.

WARFARE OF THE FUTURE

The nature of warfare and its weapons has changed to such an extent that time and space factors have been reduced materially, in fact largely eliminated. If the Germans were able in 1944 to produce a rocket which could travel 70,000 feet above the earth for a distance of 280 miles at 700 miles per hour, and deliver a ton of explosive with considerable accuracy, it is absolutely certain that any of the principal industrial nations of the earth can develop, by 1950, a more powerful rocket with a range of from 3,000 to 5,000 miles which can travel at a speed of 1,000 to 3,000 miles an hour sufficiently high to overcome the earth's curvature, and deliver 10 to 20 tons of explosives with great accuracy. When that weapon is developed, the time and space factors which have been of such good service to the United States largely will disappear.

There has been much speculation as to the effect of the atomic bomb on warfare of the future. In that category the United States Army Air Forces has installed a Deputy Chief of Staff for Air whose sole duty is the study of the effect of atomic energy and weapons on warfare, and the development of new weapons through the most advanced experimentation and research. The Army's best brains and entire scientific and experimental organization have been marshaled to think through every possible implication introduced by atomic fission and to mold the structure of the Air Forces accordingly.

In my studies of this problem, I have asked myself this question: If I had been the head of the Japanese general staff, how could I have prevented the atomic bombs from being delivered on Japanese targets? This is my conclusion: There are three ways in which this might have been done had the Japanese possessed the necessary military force. The first would have been to destroy the production capacity of atomic bombs at its source in the factories and laboratories of the United States. This would have been the most decisive and effective way. The second method would have been to destroy the bombs, and the airplanes which were to deliver them, on their bases in the Marshall Islands, before they were launched. The third possible, but doubtful, method would have been to have had a fighter defense and an antiaircraft defense throughout Japan of sufficient efficiency and intensity to destroy the airplanes carrying the bombs as they approached their target. This would have required a larger fighter force and a better antiaircraft defense than any nation in the world

Contrast between yesterday's fighting methods as shown in the Battle of the Little Big Horn (above) in which General George A. Custer and his entire command were wiped out on June 25, 1876, by Sioux on the warpath under Sitting Bull, and the destruction wrought by modern warfare as illustrated by a general view of Caen, France, after its occupation by British troops during World War II (the Battle of the Little Big Horn took place on the same Sunday that Bell demonstrated his telephone at the Philadelphia Centennial Exposition)

even has approached to date. It would have been the least efficient of the three methods and the least likely to succeed.

What kind of force would Japan have needed to accomplish the first two methods? The only weapon known to warfare today which could have accomplished these purposes—the destruction of bomb-making capacity in the United States or of the airplanes carrying the bombs (the long range bombers on bases in the Marshall Islands)—would have been a long range bomber force such as the United States alone possessed in World War II. The most powerful army and navy in the world would have been impotent to stop these bombers with their death-dealing atomic bombs. Only a long range bomber force of sufficient power to fight its way through to its targets could have saved Japan from the bombs.

BUILDING FOR THE NEXT WAR INSTEAD OF THE LAST

The United States must revamp its war plans; it must reorganize its military power for a new type of war. If Americans will realize these facts fully and prepare a military machine for the future in accordance with them, the United States still will be secure. If this is not done—if the United States insists upon building a military machine with which to win the last war instead of the next—then there will be no real security, and the tremendous cost will have been an idle expenditure.

The argument sometimes is offered that an organization which has won two wars should not be altered. Sitting Bull won the Battle of the Little Big Horn with bows and arrows. Dewey won the Battle of Manila Bay with 6-inch guns. Could anyone suggest that, because two great victories were won with antique weapons, the United States should hold fast to old means and modes and methods? Too frequently we build to win the last war instead of the next. After World War I the United States Army bought horses instead of developing tanks—but by World War II mounted combat was obsolete. The island bases that were required to stop the Japanese in the second World War may not be needed next time—if there is a next time.

There is every indication that the national defensive structure must be reorganized for a new type of warfare. I have indicated where time and space practically are eliminated. Greater speed of decision will be necessary than was attained in the last war. It is enough to say for the proposed unification of the Armed Forces—with Army, Navy, and Air Forces on coequal status—that economy in peace and efficiency in war demand it. National defense is not three problems but one.

A system of national security for the United States in the future must have these ingredients:

1. The State Department must be an organization which will offer an ample career in professional diplomacy to the best brains that the United States can produce. Unsuccessful diplomacy sounds the reveille for war; where the diplomat leaves off, the soldier must take up the burden.

2. A central intelligence agency must be organized which will gather information about conditions in every part of the world. It would be wise to borrow the techniques and energy demonstrated by foreign agents in the United States, if not their principles.

3. A force must be held in readiness to move on a moment's notice to destroy a discovered war chest of an enemy before the enemy is able to take the offensive. Defensive measures must be provided in anticipation of the worst until the United Nations proves its ability to cope with world problems.

4. Weapons must be kept up-to-date. This requires great emphasis on scientific development—research and experimentation. It has been said that every war begins with the best weapons of the last war. It well may be that, in the robot bomb, the German rocket, *V-2*, or the atomic bomb, the world was given a preview of the weapons which will dominate the next war. It well may be, too, that some of the techniques which appeared experimentally in the last war may be commonplace and routine in the next; radar, for instance, and blind bombing.

Although there is grave danger that the war of the future will be a short war of unparalled early destruction where the first blows will come through the air, if Americans are wise they nevertheless will maintain naval and land forces, modern and mobile, the whole to be supported by a National Guard and Organized Reserve, and a Reserve Officers Training Corps prepared to mobilize and lead the man power of the nation. Then, too, there must be better plans for the conversion of industry to warfare than have been formulated in the past for the simple reason that there will be less time, plus the great probability that this conversion will have to be accomplished under attack by the enemy.

This much is certain. There is the greatest probability that the first battlefields of the next war will be the industrial cities of the United States. No aggressor nation of the future can miss the point that the last two wars were lost by the aggressor because he neglected to depreciate American man power or to destroy American resources.

IMPORTANCE OF NATIONALISM

Finally, over all this business of sound organization, modern weapons, and mobilized industry and man power, is this dominant fact—no nation is secure unless the citizen places the welfare of his country above his personal self-interest. During the war national interest was paramount. Now there are many signs and there is grave danger that the self-interest and personal welfare of highly organized minorities, such as the labor unions, are being placed above national interest, the welfare of all the people. Another war can be waged successfully only if groups such as labor and management are able to meet constructively and iron out their differences in deference to a common cause.

As the first plank in a platform for national security then, let us make certain that the future generation is educated to put national interest first.

Physics Today—Engineering Tomorrow

C. G. SUITS
MEMBER AIEE

The development of the magnetron is a typical story of a device which has passed down the technical "production line" from a principle of physics through engineering development to an operating device. This example illustrates not only the infinite possibilities that exist in the field of science, but the fact that the development of these possibilities is a process which transcends the efforts of any single individual or organization.

THE SUBJECT of this article is the relationship between physics and engineering. At first thought, it would seem unnecessary to point out to engineers that today's principles of physics will become tomorrow's engineering practice. We see this transition from principle to practice taking place every day. Nearly every technical man is a specialist. He works on the technical production line that moves from fundamental research to applied research and advanced development, to engineering study and design, and finally to production and practical use by the public. This is a long line, long in terms of human efforts, usually much too long in terms of the time required for a new principle of physics to traverse it from start to finish. From where the engineer stands, somewhere near the middle, it is difficult to discern clearly both ends of the line, and hence to realize that these engineering principles in common use today were part of the domain of physics only yesterday. Wartime experience provided an excellent opportunity to witness this transition, because under the dire necessity of war, and incidentally the somewhat prodigal assistance of the United States Treasury, the whole process of translating science into useful devices was accelerated tremendously.

In an article addressed to engineers, one should be specific, and so I will illustrate my theme by an example of this transition from physics to engineering; the development of the magnetron. The whole history of this fascinating electronic device has taken place within the memory and experience of most readers, and because the laboratory with which I am associated has contributed to the story at several points, I believe that it would be an interesting case history to examine in some detail.

The history of the device is by no means a closed book. In fact, some of the most interesting chapters are being written by engineers today, and so it should be a timely example. Furthermore, the story of the magnetron is relatively little known in its entirety.

THE STORY OF THE MAGNETRON

The first magnetron was built in 1921 by Doctor A. W. Hull. The tube is simplicity itself, consisting of a cylindrical anode, a concentric tungsten filament, and a coil providing a coaxial magnetic field. Doctor Hull discovered that this tube could be used as a generator of oscillations, and as an audio-frequency amplifier, and a considerable number of the tubes were made and used in 1921, 1922, and 1923 as synchronous detectors for trans-Atlantic radio telegraphy, as well as for some other purposes.

Tubes such as these also were used to measure magnetic fields. One magnetron of this type was loaned to the United States Naval Laboratory at Newport, R. I., for surveying the magnetic fields under ships. A civilian scientist, Minckler, who had charge of these measurements, accomplished the unprecedented feat of completing the whole survey with one magnetron and returning it in good condition.

Magnetrons similar to the earliest device, but larger, were used experimentally to generate long-wave radio frequency oscillations, giving 10 kw in the frequency range from 20 kc to 50 kc. The circuit employed was that of a back-coupled amplifier, using a variation of the magnetic field as a control principle.

This early magnetron, however, did not find a real place in technical economy at the time and remained something of a laboratory curiosity for many years. It illustrated some interesting principles of physics, but did not develop any engineering opportunity. Workers in Japan and at several points in Europe, however, made some significant contributions to the development of the magnetron during this period. For example, in 1924, Zacek, a student at the University of Prague (Czechoslovakia), obtained weak oscillations with a magnetron

Essentially full text of an address presented during the National Electronics Conference, Chicago, Ill., October 3–5, 1946.

C. G. Suits is vice-president and director of the research laboratory, General Electric Company, Schenectady, N. Y.

at wave lengths as short as 29 centimeters. This work was published in Czechoslovak and was not generally known until a great many years later. Also in 1924, Erich Habann at the University of Jena (Thuringia, Germany) showed that a magnetron with anode split into two halves had a negative static resistance and hence was capable of generating oscillations. He obtained 11 watts of radio-frequency power, presumably at a rather low frequency. In 1928 two Japanese, Okabe and Yagi, announced the production of waves as short as 5.6 centimeters with this type of magnetron. Some of these split anode magnetrons were manufactured in the United States in small quantities in 1928, but they did not have a satisfactory market and were withdrawn from production.

Between 1930 and 1940 there was continued research, chiefly in Japan and Germany, on both single anode and split anode magnetrons, but no new principles came out of this work. E. G. Linder of the Radio Corporation of America, in 1935, obtained 2.5 watts at a wave length of 9 centimeters with a single anode magnetron operating with the end-plates at positive potential. C. W. Rice, General Electric Company, operated a single-anode magnetron in a symmetrical but convergent magnetic field at about this time, and generated 5 watts at a wave length of 5 centimeters. C. E. Cleeton and N. H. Williams at the University of Michigan obtained oscillations at a wave length of 1.1 centimeters with a simple split-anode magnetron of miniature dimensions.

The next important advance was made in Russia. On April 28, 1940, Alekseev and Malairov reported in the *Russian Journal of Technical Physics* a series of experiments made in 1936 and 1937 with multicavity magnetrons with four cylindrical cavities in a solid block of copper. With this device, identical in appearance with the British pulsed magnetron of Randall, they obtained an output of 116 watts at 9.1 centimeters with 22.5 per cent efficiency. With smaller tubes of the same type, they obtained 20 watts at 5.5 centimeters and 2 watts at 2.6 centimeters. This work was not known in the United States until it was reprinted in English in the *Proceedings* of the Institute of Radio Engineers in 1944. In February of 1940, Doctor J. T. Randall of St. Andrews University in England developed the first pulsed multicavity magnetron for 10-centimeter operation. A few months later, Sayers of Birmingham University, England, invented strapping. Samples of these early pulsed tubes were brought to the United States at about this time and were developed further under National Defense Research Committee sponsorship and in some industrial laboratories, particularly those of the Bell Telephone Company and the Radio Corporation of America. The radiation laboratory of the Massachusetts Institute of Technology took a prominent part in this work also and carried the 10-centimeter pulsed magnetron to the astounding output of 2 megawatts peak power. Today, of course, the multicavity pulsed magnetron is the principal transmitting tube for microwave radar sets. It is suited particularly to the generation of very large pulses of power for very short periods of time.

As the duty cycle of the tubes is characteristically short (for example, a few microseconds pulse duration for a repetition rate of 1,000 per second), the average power of these pulsed tubes is generally quite low. The highlights of magnetron development up to this time had been, first, the invention of the elementary type in 1921, followed by the discovery of multianode operation, and finally the development of the multicavity strapped magnetron for very high power pulsed operation.

RADAR JAMMING

A next, and vital, step in magnetron development originated in a problem, which arose early in World War II, when the German battleships, the "Scharnhorst" and the "Gneisenau," successfully ran the gamut of the British coastal guns at the Straits of Dover. An important factor in the success of this operation was the blinding of the British coastal radar by jamming transmitters carried by the German vessels. The success of this operation called attention to the vulnerability of radar to jamming, and a very great technical effort subsequently was launched in the United States to develop the most effective possible means of blinding enemy radar. Radar was, by this time, an indispensable element of military and naval operations with all of the principal belligerents, and there was correspondingly a tremendous premium placed on any encouragement of its malfunctioning. Jamming enemy radar turned out to be a very successful operation which had a considerable bearing on the final outcome of the war in Europe. The jamming power required to screen a heavy bomber from enemy radar frequencies turned out to be of the order of a few watts, and this generally was met by triodes and pentodes of more or less conventional design. The ether smoke screen required to hide a naval vessel or a fleet of heavy bombers by jamming is quite another matter, however, and it was in connection with this problem that further important steps in the magnetron's development were taken. For the development of these superpower jamming transmitting tubes, a number of industrial laboratories initiated projects in 1943 and 1944 under the sponsorship of the NDRC. An investigation of this problem showed that the magnetron had tremendous possibilities for the generation of continuous power at a very high level, as well as for the generation of the powerful short pulses required in radar. Thus the development of radar as a military weapon, which owes so much to the magnetron tube, became itself very vulnerable to the radiations from this same type of tube used as a jamming device.

The tubes, which were developed for radar jamming

as continuous radio frequency power generators, are very efficient, the efficiency generally lying in the range between 50 per cent and 85 per cent. Furthermore, these tubes are tunable and a very considerable tuning range may be experienced in practice. Magnetrons also may be amplitude or frequency modulated, but much more work must be done on this problem before thoroughly satisfactory results are achieved. Many of these results were obtained under government contacts and accordingly are public property.

A number of important advances have been made in magnetron design in the course of reaching these spectacular results. One of these has been the invention of a neutrode principle by Doctor Wilbur of the General Electric Company, which, together with a careful study of electron paths in the magnetron, has made possible some of these results. The end result of the long history of magnetron development is very important. There is now available a variety of simple and easily manufactured magnetrons which produce kilowatts of power in the 1,000-megacycle frequency range, where only a few watts could be generated prior to World War II. Some new industries are going to be founded on this result. We now have available for the first time the means for heating insulating and dielectric bodies on an industrial scale. The heating of metals by frequencies in the kilocycle range, for example, the high frequency melting of alloys, and the high frequency heat treating and case hardening of alloys, were made possible by the ready availability of kilowatts of power in the kilocycle range. We now have kilowatts in the *1,000-megacycle* range and some very important uses for this power are in the process of development

FROZEN FOOD THAWING

Heating of food unquestionably will be one of these important uses. Although the *cooking* of food presents some unsolved problems, the quick warming of cooked food and the thawing of frozen food both offer attractive potentialities. Anyone who has a frozen food cabinet is aware of the practical difficulty of quickly thawing food which is removed from the cabinet. For example, 30 pounds of frozen meat cannot be thawed by ordinary methods in less than two days. One thousand megacycle power may be a satisfactory answer. If it is this process should find widespread application with hotels, restaurants, air lines, and bus companies for whom the quick thawing of frozen foods will open up some interesting operating possibilities. There is no significant reason why the housewife of the future should not purchase completely frozen meals at the grocery store just as she now buys quick frozen vegetables. With a quick heating, high-frequency unit, food preparation from a precooked, frozen meal is a simple matter.

There are also some very important industrial applications for 1,000-megacycle power. Power and frequency now are available for heating almost any insulating body. For example, enough power is obtainable at the right frequency to melt quartz. One important application of 1,000-megacycle power is in the plastics industry. In the molding of plastics, the following process generally is employed. The part to be molded is supplied to the molding machine in the form of a small slug. This slug is heated, inserted in the machine, retained for a time at temperature sufficient to cure or polymerize the resin, and then ejected as a finished part.

The whole time required for accomplishing this cycle determines the use factor of the molding machine. This use factor may be improved tremendously by the use of 1,000-megacycle power. In one characteristic situation, the fastest cycle possible by conventional practice was 30 seconds. By the use of 1,000-megacycle power supplied by magnetrons, this whole cycle was reduced to 7 seconds. This spectacular result may be applied rather widely in the plastics molding industry and shows promise of revolutionizing this industry. Because the heat is applied internally rather than externally, the heating of the part to be molded may be accomplished more quickly. Because the heating is quicker, the temperature may be higher without harmful decomposition of the polymer. Because the temperature is higher, the cure is accomplished more quickly, the mold may be simply a cooling device, and reductions of over-all time of 3-fold to possibly as much as 20-fold are possible.

The development of 1,000-megacycle power bespeaks the development of new industries and of important new segments of the electronics industry. Some of these segments ultimately will be more important in their magnitude than the radiobroadcasting industry is at present.

From this example of a development which ran the gamut of science and engineering and now is emerging at the far end of the production line as a factor in everyday life, some important observations may be made.

First, we must see to it that new scientific principles are discovered and started down the line. These new principles commonly come from purely exploratory research on fundamentals. We must not expect to foresee nor to predict the end result of such fundamental research. The important thing is that it be conducted in new areas of science, where opportunities for new knowledge exist.

Second, in modern science and engineering, no one individual or organization can do the whole job. The final result is the fruit of many workers' efforts all along the line. Therefore, we must publish our individual results promptly so that they may be augmented by others, and developed further, and be reinterpreted and extended by all workers in all countries. The final result, like the magnetron, is a translation from physics to engineering, which transcends the individual efforts of any one of the workers who contributed to its progress along the line.

Electrical Steering of Ships

ROBIN BEACH
FELLOW AIEE

UNTIL the recent extensive shipbuilding program, necessitated by the imperative needs of World War II, the full electrical steering of ships had been little used in the United States, and particularly on cargo ships and tankers. During the war emergency, however, many of the new ships were equipped with steering facilities for full electric drive and control. Also the Navy, in its vast expansion, employed full electrical steering on many of its ships.

Uninterrupted, sensitive, and immediately responsive steering control on shipboard is of utmost importance to safe navigation. Most American-built ships have employed steam-engine drive or electrohydraulic gear operated by telemotor control for turning the rudder because of its relatively simple operation and construction. World War II saw the United States utilize electrical steering with complex relay and contactor circuits. The AEG Ward Leonard system described here has been used extensively abroad where marine designers and operators have held strong aversion to power contactor switches and relay controls in steering equipment.

In the United States, the conventional steering systems on shipboard commonly have employed some form of steam-engine drive or electrohydraulic steering gear for turning the rudder. The valves of the steam engines or pumps frequently are operated from the steering wheel through telemotor control. These steering systems, being essentially mechanical, possess relative simplicity, and their operation and maintenance require a minimum of electrical knowledge on the part of the engine-room personnel.

European practice, however, has been inflected, for many years, in the direction of utilizing full electrical operation and control for steering. This applies not only to the smaller naval craft of such countries as Italy, Germany, France, and England; but also, this system has been employed extensively on their cargo ships and tankers. On these classes of ships they have employed most generally the Ward Leonard power supply system, articulated with the AEG (Allgemeine Elektricitäts Gesellschaft) electrical control. Marine engineers, abroad, long have had an aversion to employing contactors in steering power and control systems. The circuits and the equipment of the AEG Ward Leonard system are most ingenious and at the same time simple, rugged, and easily maintained. For controlling the operation of the steering motor in turning the rudder through its 35-degree port and starboard arcs, less than a dozen control wires are necessary and no relay contactors are used.

The full electrical steering of ships, where used in the United States, is accomplished by the extensive use of relays and contactors whereby the control of the steering motor is essentially similar to that for elevator motors. Large panelboards are employed for mounting the relays, solenoids, and heavy contactor switches by means of which the starting of the steering motor, its acceleration and speed control, its reversal, and its braking operations are obtained in the conventional manner. One such system is shown in Figure 1. The Sperry system, of which the illustrated equipment is a part on one large American tanker, utilizes an ingenious steering transmitter and follow-up controller; but its operation requires a complement of control relays and power contactors. Presently adaptations of the amplidyne and Rototrol will be applied to electrical steering, and they may prove to be competitive systems.

Because of the general use of the AEG Ward Leonard system abroad, wherein many foreign ships equipped with it put into American ports for repairs or are purchased by American shipping interests, an explanation of the operation and control principles embodied in this system is presented here both for its general interest and specific value.

THE WARD LEONARD POWER SYSTEM

The power supply for operating the steering motor which actuates the rudder is obtained from the d-c generator of a 3-unit motor-generator set. The motor of this motor-generator set, usually a compound-wound type, is operated from the ship's 230-volt d-c electric supply. It drives the direct-connected generator, also compound wound, which is connected electrically directly to the armature terminals of the steering motor without intervening switches, and the variable and reversible generator voltage is controlled by field current which it obtains from a pilot exciter, the third unit of the 3-unit motor-generator set.

On large cargo vessels and tankers, the steering motors

Robin Beach is head of Robin Beach Engineers Associated, Brooklyn, N. Y.; associate of McCrossin and Company, Engineers, New York, N. Y.; and is adjunct professor of electrical engineering, Polytechnic Institute of Brooklyn, N. Y.

have a rating of the general order of 25 to 35 horsepower at 175 volts, based on an intermittent 10-minute rating. On the same basis, the rating of the generator drive motor ranges from about 35 to 50 horsepower, the main generator from about 25 to 35 kw, and the exciter from about 0.5 to 1.0 kw.

The pilot exciter is a small, separately excited, d-c generator, whose armature is connected electrically, without an interposed rheostat, to the main field circuit of the generator. The field winding of the pilot exciter consists of two exciting circuits, differentially wound, so that when the two field windings have balanced currents, the net magnetic excitation is zero. In this case, the armature supplies no exciting current to the main field circuit of the generator, and, in turn, no power is delivered to the steering motor.

Figure 1. Steering engine of a large American-built tanker

Characteristic electric circuits of the motor-generator set and of the steering motor, as they commonly are employed in electrical steering, are shown in Figure 2. The main and series fields of the steering motor are energized whenever the motor-generator set operates, the main field having constant excitation from the ship's supply while the current in the series field varies with the load on the continuously operating main motor. Hence the steering motor is sensitive to the smallest armature current, and it begins to operate as soon as this armature current develops sufficient torque to overcome the static friction of the steering mechanism.

CONTROL OF THE PILOT EXCITER

The differential field circuits of the pilot exciter—F_1 and F_2 (Figure 2)—are energized by the two currents of the electric steering control system which currents are modulated by virtue of the mechanical movement of the steering wheel, located on either the bridge or the afterdeck. In order that this pilot exciter be sensitive to the slightest movement of the steering wheel, the differential field windings and their common magnetic circuit are so designed as to create a maximum change in the response of the magnetic field to the least variation of the control exciting current, and particularly so in the region of low magnetism.

This sensitivity is achieved effectively in three ways:

1. By winding the exciter field coils differentially on the magnetic structure.
2. By creating a large unbalance in the two exciter field currents through a minute movement of the steering wheel.
3. By designing the magnetic circuit of the pilot exciter to possess a relatively large magnetic response for a small change in the exciting currents.

In this manner, even the slightest movement of the steering wheel causes an appreciable unbalance of the control currents in the two differential field circuits, one current increasing as the other correspondingly decreases.

Thus, a slight variation of the control currents in the field circuits of the pilot exciter amplifies the resulting response of its magnetic field, the excitation supplied to the main generator, and the starting torque developed in the steering motor. Whichever of the two control currents in the differential field circuits is made the larger determines the direction in which the magnetic field develops and, hence, the direction in which the steering motor rotates.

ELECTROMECHANICAL CONTROL SYSTEM

The function of the electromechanical control system (Figure 3) is to translate the steering order of the pilot wheel, imparted by its rotation, through the variations of current in the two differential field circuits of the exciter, into a proportionate movement of the rudder by its steering motor. The rudder should respond to the position ordered by the steering wheel rapidly, at first, after which the rudder approaches its final position gradually and attains its objective without overshooting it.

Hence, the movement of the steering wheel initiates

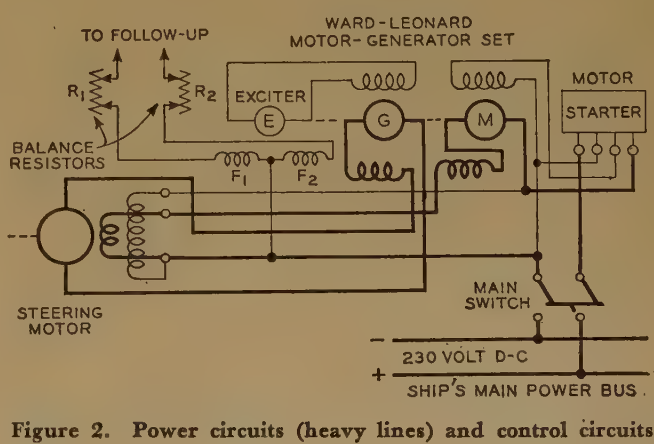


Figure 2. Power circuits (heavy lines) and control circuits (light lines) for an AEG Ward Leonard electrical steering system

the development of relatively high torque in the steering motor which causes rapid movement of the rudder; but, as the rudder turns, a servomechanism, associated with it, introduces subsequent control of the motor torque, gradually decreasing it to zero as the rudder reaches its ordered position. This servomechanism commonly is called a follow-up, rudder-watcher, or receiver, all being appropriate names which describe its function in the system. In order to re-establish the balance of the two currents in the differential fields of the pilot exciter when the rudder reaches its ordered position, the follow-up obviously must be associated both with the mechanical turning of the rudder and with the electrical circuits of the control system.

From this, it can be seen that, depending upon the desired steering direction of the ship, the turning of the steering wheel must actuate a mechanically articulated transmitter in the deck house which unbalances, one way or the other, the two currents in the differential field circuits of the pilot exciter. The operation of the follow-up unit, mechanically articulated with the movement of the responding rudder quadrant, must provide subsequent control over the currents in the two electrical control circuits, progressively reducing the net excitation of the differential fields within the pilot exciter by restoring the balance of these currents.

As shown in Figure 4, the transmitter contains nine stationary brush contacts, to which nine control conductors are attached. The moveable system consists of essentially two groups, each of four narrow segments disposed uniformly on either side of a wide central segment. The segments are insulated from one another and from ground, and all are connected in sequence to a graduated tapped resistor, whose mid-point is connected both to the moving central segment and to the positive line of the ship's electric supply through a brush and slip ring.

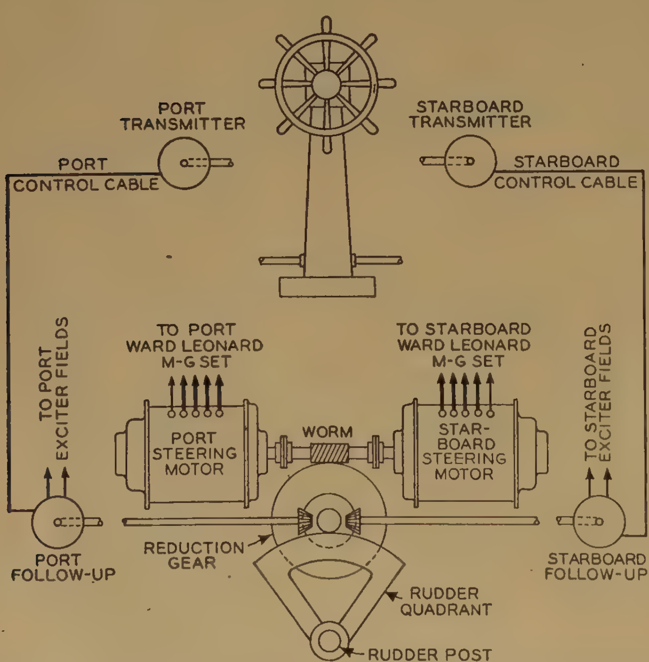


Figure 3. Schematic diagram of a dual AEG electromechanical steering control system

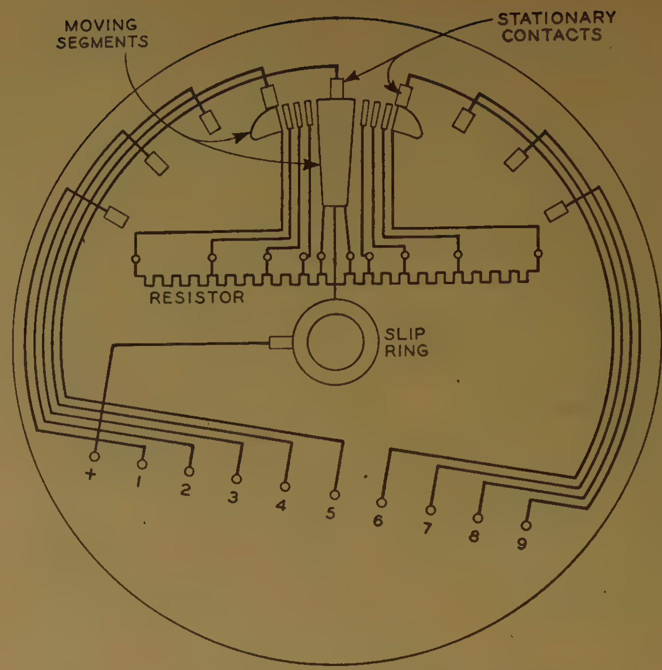


Figure 4. Detail of AEG steering control transmitter

THE FOLLOW-UP

Although the follow-up (Figure 5) posesses some similarity to the transmitter, it differs in a number of essential mechanical and electrical features. The moveable system consists of two sections of a split brass ring and nine narrow segments, all parts being insulated from each other and from ground. The mid-segment, unlike that of the transmitter, is not only narrow like its neighbors, but also it is electrically dead. The four segments on one side of the dead segment connect to a graduated tapped resistor which is joined to the ring section on that side, and the other four segments on the opposite side of the dead mid-segment are connected to a second graduated tapped resistor which is attached to the other ring section. There are 11 fixed brush contacts which bear upon the two sections of the split ring and upon the segmented system between the ring sections. Nine of these are the terminals of the control wires from the transmitter. The remaining two fixed brushes, one on each side of the group of nine control contacts, are connected to the differential field windings of the pilot exciter. One of the field brushes always bears upon one section of the split ring, and the other field brush similarly rests at all times upon the other split ring.

Figure 6 shows the rudder control system in a balanced condition at about 23 degrees left. In this position the flux produced by the differential fields F_1 and F_2 are balanced and opposed which results in zero net excita-

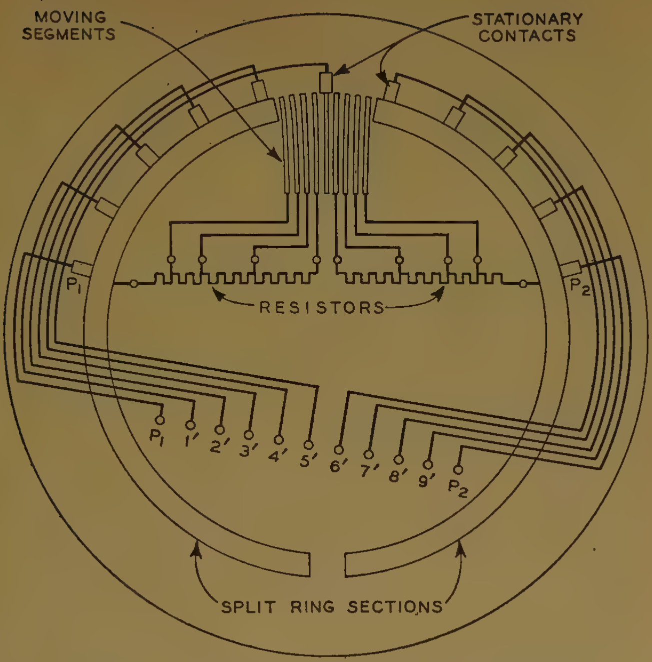


Figure 5. Detail of AEG steering control follow-up

tion of the pilot exciter. Adjustment for this condition is achieved through manipulation of resistors R_1 and R_2. If the steering wheel is spun rapidly to the amidship position the moving elements of the transmitter and follow-up units assume the positions shown in Figure 7. For such relative positions the exciter field circuits are in the extreme unbalanced condition with zero current in one and maximum current in the other, thereby permitting maximum excitation resulting in maximum steering motor speed.

As soon as the transmitter is moved the follow-

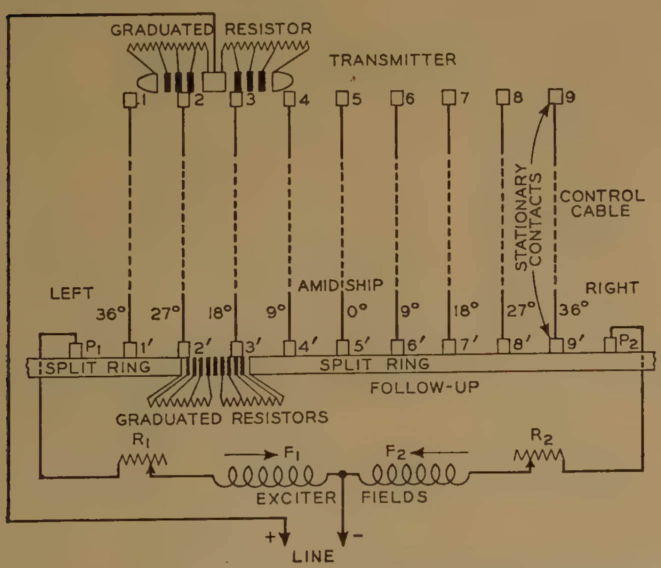


Figure 6. Developed diagram of an AEG steering control system in balanced condition at about 23 degrees left

up begins to function in co-ordination with rudder movement. When the rudder approaches its ordered position the moving contacts of the follow-up reach a position where they commence to introduce resistance in one exciter field circuit and reduce resistance in the other exciter field circuit which thereby reduces the net excitation and consequently slows the rudder movement. The resistance steps of the transmitter and follow-up units are graduated so that motion of the rudder will be rapid at first and then will slow down to approach its ordered position gradually without overshooting.

When the steering wheel is being turned repeatedly for small corrective steps, as in trying to maintain a straight course, the most sensitive operation and control requires that the magnetic circuit of the pilot exciter be designed for minimum residual magnetism for response to the least coercive force, in order to permit reversed excitation of the exciter for the slightest reversal of the two unbalanced field currents. This characteristic sensitivity is particularly desirable in the use of automatic steering gyroscopes.

DUAL STEERING SYSTEMS

Many of the larger ships of the merchant class and tankers, and practically all of the naval vessels, which employ AEG Ward Leonard system electric steering, are equipped with dual steering systems. This dual arrangement contributes a high degree of reliability in providing continuity of steering facilities—a desirable safety factor in recognition of the importance of unfailing steering control at all times. In such cases, two complete 3-unit motor-generator sets, each with its own independent electric control system, and two steering motors, each coupled to the common worm shaft of the worm-gear drive for the rudder quadrant, are employed. Such a dual set of steering motors for a large European-built tanker is shown in Figure 8. Each motor is connected electrically to its own motor-generator set, thus one being independent of the other.

Also, it is good practice, and common experience, to provide a transfer switch in the control cable between a transmitter and its follow-up, whereby the steering control may be transferred from the pilot house to the afterdeck, or vice versa, in case of damage to steering equipment at either one of these two steering stations.

STEERING OPERATIONS IN HARBORS

The important advantage of unfailing service which should be available for operating through harbor traffic by virtue of having on board dual motor-generator sets and steering motors is not utilized effectively as these AEG steering systems now are employed. Because of the manner in which the electric connections of the dual steering systems are used currently, the alternate motor-generator set cannot be placed in operation for immediate service should a fault occur to the operating motor-generator set.

If the alternate motor-generator unit is assumed to be running during stand-by service, its steering motor would be driven by the worm shaft from the operating steering motor during steering operations; and, because the main and series fields of the alternate steering motor both would be energized, it would act as a generator and develop electric power. In this situation for stand-by service, of course, the control system of the alternate unit would not be connected for operation, and for this reason the main field of the alternate generator would not be energized by its pilot exciter. But the alternate steering motor acting as a generator, when driven by the worm shaft, would tend to drive its main generator as a series motor under the condition of very weak field, and hence the armature of the main generator would constitute essentially a short circuit on the steering motor. In this manner, the entire electrical system of the ship might be overloaded and the motor-generator sets and steering motors might be seriously overheated.

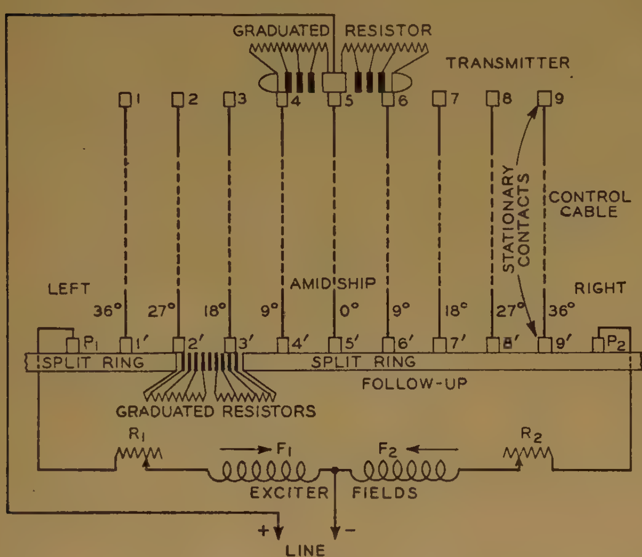


Figure 7. Same system as in Figure 6 with transmitter shifted to amidship position and follow-up in position corresponding to beginning of rudder response at about 23 degrees left

METHOD OF CORRECTION

This entire situation readily could be corrected by the use of one double-throw 8-pole switch located conveniently in the engine room. When thrown one way, the switch would make one unit operative; but in the other unit a short circuit would be placed across the series field of the steering motor, and the main field of the steering motor and the positive potential line to the transmitter would be opened. This would permit the alternate unit to run concurrently with the operating unit as desired, but without the ill effects stated before.

If trouble occurred to the steering system while one unit was operating and if the alternate unit already were running, as it should be when a ship is maneuvered through harbor traffic, the double-throw switch would be thrown over immediately, thereby removing the faulty unit from service and simultaneously connecting the alternate unit for steering operation. The throwing over of this switch would require only a few seconds, thus avoiding continued impairment of the ship's steering control.

Figure 8. Steering engine of dual type AEG Ward Leonard system in European-built tanker

The peculiarities of the present wiring are such that the reserve unit cannot be started and brought up to speed until after the in-service unit has been stopped. These operations, if performed promptly, require from three to five minutes, during which period the ship's steering system is wholly inoperative. This inflexibility of the present dual system, which in all other respects is excellent, has led to occasional collisions of ships maneuvering through harbor traffic.

RELIABILITY

Because reliable steering facilities on shipboard are of utmost importance to safe navigation, diligent attention should be given to the choice, care, and maintenance of the equipment. For maximum safety and reliability in steering service the equipment and controls should be simple, rugged, and dependable. Dual steering equipment and controls, where they can be employed, offer the highest degree of reliability and such provisions may pay large operating dividends in avoiding collisions. Perhaps the challenge for simplicity and ruggedness of equipment and circuits for electrical steering of ships—as exemplified by the AEG Ward Leonard system—may be one worthy of especial consideration in promulgating the highest degree of reliability, safety, and service for all electrical steering systems.

Postwar Television Receivers

D. W. PUGSLEY
ASSOCIATE AIEE

Knowledge gained from wartime research in microwave techniques is being applied to improve the peacetime design of television receivers for home use. Receivers now are available which incorporate these radical changes in design.

THE new postwar television receivers include many new design features and characteristics which result in a much superior product to the consumer, not only from the standpoint of performance, utility, and reliability, but also from the standpoint of minimum obsolescence.

RECEIVER TYPES

The majority of receivers in this postwar era fall into two categories—direct view and projection. Direct view receivers, as the name implies, are receivers designed to allow the user to view the picture directly on the screen of the picture tube. In the projection type receivers, however, the picture first is formed on the screen of the cathode-ray tube, and then is magnified optically and projected onto a viewing screen. In most, if not all, cases the screen is a part of the cabinet, and is not a separate detachable piece such as is used with home movie projectors. Another type, the indirect view receiver, was quite common before the war but is now largely obsolete. This was a type wherein the picture formed on the screen of the tube was viewed not directly, but by means of a plane mirror set at an angle of 45 degrees to the vertical. A fourth type, which has no particular name, is a modification of the direct view type wherein the picture is viewed through a large "magnifying glass" or condensing lens which is placed directly in front of, and close to, the picture tube. This type seldom is used, primarily because the condensing lens limits the field of vision.

EXTERNAL DESIGN FEATURES

Figure 1 shows a new direct view television receiver and Figure 2 shows a new projection type receiver. If the artistic appearance of a television receiver is considered, it is necessary to conceal the screen when it is not in use. Two solutions to the problem are shown in Figures 1 and 2. In the projection type receiver the "doghouse" (the screen and mirror housing) is counterbalanced. A force of only about $4^1/_2$ pounds is required to raise or lower the entire mechanism although the total weight is 40 pounds. An "anti-finger-pinching" device is incorporated in this model.

CHASSIS AND CIRCUIT DESIGN

Figure 3 shows the chassis of the direct view receiver of Figure 1 with the shield removed. This chassis is complete with all the components necessary for both television and standard radio broadcast reception, except for the loudspeaker which is necessarily mounted to the cabinet for accoustical reasons. As can be seen, even the cathode-ray tube is securely mounted on the chassis. It is left there even during shipment. This has proved to be a real step forward from the old prewar scheme of shipping the tube separate from the chassis.

Certain design considerations are of extreme importance in that they affect not the user's reception, but may interfere seriously with a neighbor's television or radio reception. Many readers will recall that during the early days of radio a very cheap but very sensitive circuit known as the superregenerative detector was put into many radios. This circuit worked well as far as receiving signals was concerned, but unfortunately it also radiated spurious signals of its own through the antenna, with the result that neighboring receivers for blocks around were filled with miscellaneous whistles and squeaks. This circuit subsequently was outlawed.

A similar condition can exist with television receivers unless proper design considerations are taken into account by all receiver manufacturers. However, in the case of television receivers this condition is more serious in that even though a straight superheterodyne receiver is used intolerable interference may result. In this case it is radiations from the local oscillator of the intermediate-frequency stage that may interfere with the sound or picture of a neighboring receiver.

Table I. Television Channel Frequency Allocations

Channel Number	Frequency Band, Megacycles	Channel Number	Frequency Band, Megacycles	Channel Number	Frequency Band, Megacycles
1	44–50	5	76–82	10	192–198
2	54–60	6	82–88	11	198–204
3	60–66	7	174–180	12	204–210
4	66–72	8	180–186	13	210–216
		9	186–192		

Essential substance of paper 47-73, "Postwar Television Receiver Design," presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

D. W. Pugsley is section leader at the General Electric Company, Bridgeport, Conn.

Figure 1. A direct view television receiver shown while not in use (center), arranged for radio operation only (left), and in condition for television reception (right)

The Radio Manufacturers' Association has taken cognizance of the oscillator radiation situation, and has issued memoranda to manufacturers strongly stressing the need for mutual co-operation in the design of receivers which will not cause serious radiation interference.

One of the best ways, and almost the only practical way, of reducing oscillator radiation to reasonable levels is to provide a properly designed radio-frequency stage in the input section of the receiver. This of course adds cost that would not otherwise be necessary, but which is essential to the public's best interests. It will be most unfortunate if some manufacturers seize upon this condition as affording a source of lucrative cost reduction.

Another source of interference that may come from poorly designed sets is the type of radiation that is created by some types of radio-frequency or "fly-back" high voltage supplies when not properly shielded. This type of interference does not bother television receivers, but does play havoc with radio receivers in the immediate area. Here again this source of annoyance is completely eliminated in reputable receivers which incorporate adequate shielding.

It was the custom in prewar receivers to use a 60-cycle

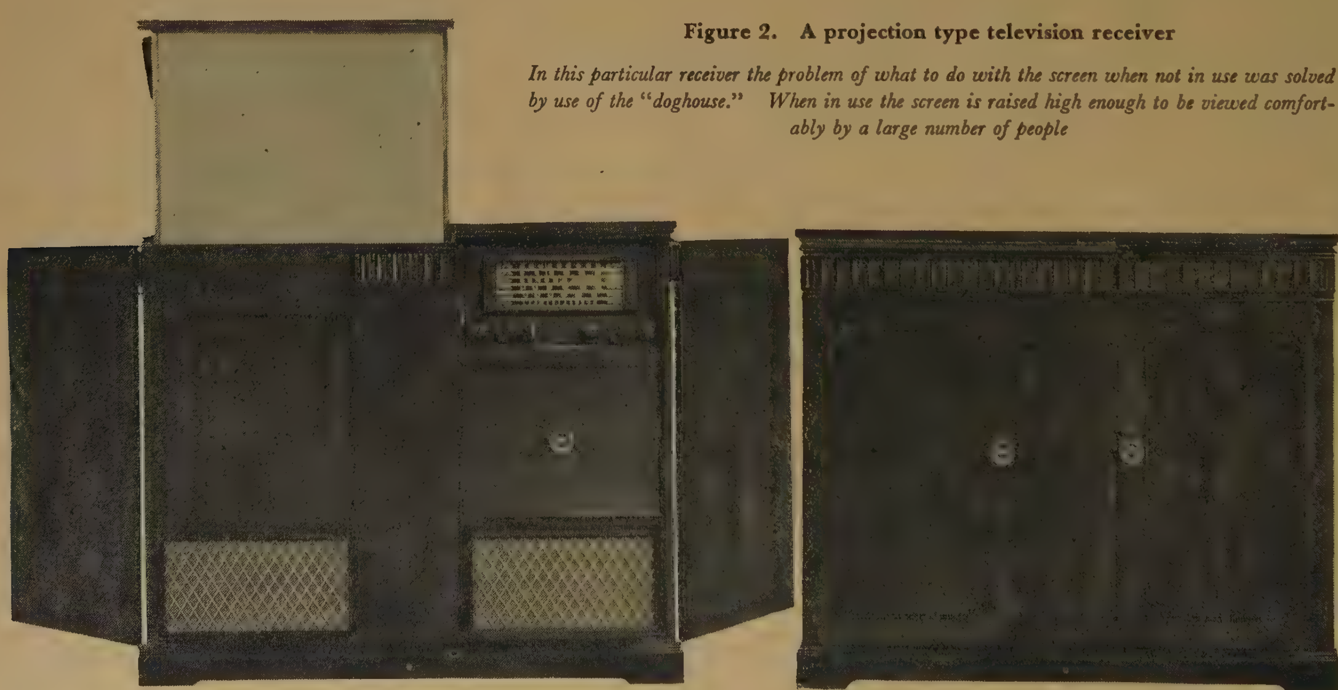


Figure 2. A projection type television receiver

In this particular receiver the problem of what to do with the screen when not in use was solved by use of the "doghouse." When in use the screen is raised high enough to be viewed comfortably by a large number of people

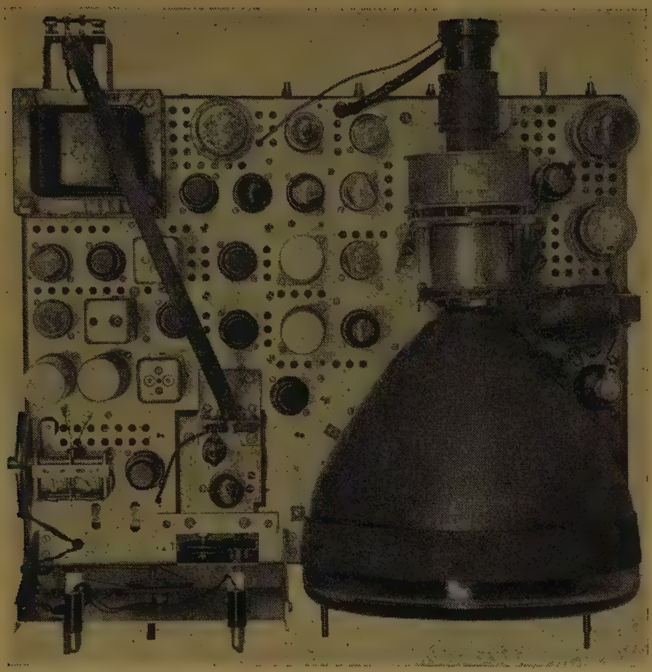


Figure 3. Top view of chassis of modern television receiver shown in Figure 1

supply wherein a high voltage power transformer was used with a conventional rectifier circuit to obtain the necessary high direct voltage for the final anode of the picture tube. In prewar receivers this voltage was usually in the order of 2,000–5,000 volts, but in modern receivers it is seldom less than 6,000 volts and may run as high as 12,000 volts on direct view receivers, and 30,000 volts on projection receivers. As a first reaction it would appear that the use of such high voltages necessarily would entail large bulky equipment, and also would be extremely dangerous. If the obsolete prewar 60-cycle supplies continued to be used that would be true. However, this danger may be eliminated by the use of a supply which cannot deliver a dangerous amount

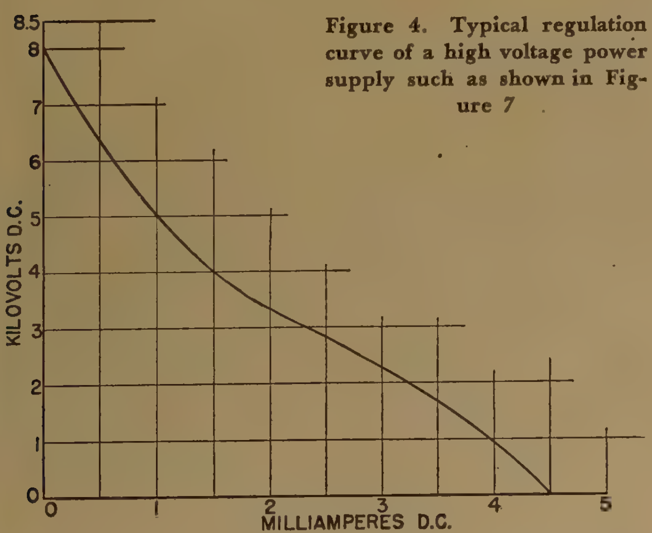


Figure 4. Typical regulation curve of a high voltage power supply such as shown in Figure 7

of current before the voltage drops to a very low level. A typical regulation curve of a high voltage power supply is shown in Figure 4.

HIGH VOLTAGE GENERATION

In this type of supply the voltage is generated by vacuum tube circuits operating at frequencies which usually range between 30 kc and 500 kc. An oscillator tube incorporates a tuned tank circuit in its plate as shown in Figure 5. There is an extension on the plate winding which raises the voltage to the desired value. This voltage is then rectified, filtered, and supplied to the final anode on the picture tube. Usually about 8,000 to 10,000 volts can be obtained in this fashion.

For projection type receivers voltages in the order of 27,000 to 30,000 volts are necessary. These voltages are obtained from a similar circuit except that voltage multiplying is employed. Figure 6 shows the schematic diagram of such a circuit.

The equipment required by such a type of supply is surprisingly small and compact. Figure 7 shows a typical supply which delivers 30,000 volts. This figure shows all the major components except for the coil which is not visible.

TUNER UNITS

Present day frequency allocations call for 13 different television channels distributed in the spectrum from 44 megacycles to 216 megacycles (Table I). Frequency allocations are such that there will be a maximum of 8 channels assigned to any major metropolitan area.

Any worthy television receiver must be designed so as to allow operation on any of the 13 channels. The best designs of receivers provide 13 operable channels all permanently connected and aligned for use. Such a set is usable at any place in the country where signals are available. No shifting of connections or realignment is required if the purchaser moves to a new location. A tuner unit incorporating all 13 channels preset need not be extremely complicated or bulky. A 17-position selector switch may be used to incorporate all 13 television channels as well as radio and phonograph services if desired. The coils for each channel can be extremely simple, and each can be permanently aligned at the factory for optimum performance.

Some receivers will be provided with only eight channel selection positions. Each channel however will be adjustable to two or more different channels. With this type of receiver it will be necessary for the service man to align each receiver for the particular stations in the area, somewhat like setting up push buttons on a radio receiver. The 8 channel selector method, while it is less expensive than the 13 channel system, may be inadequate in areas between large cities such as Philadelphia and New York where acceptable signals could be received from each city.

Other receivers incorporate a continuous tuning

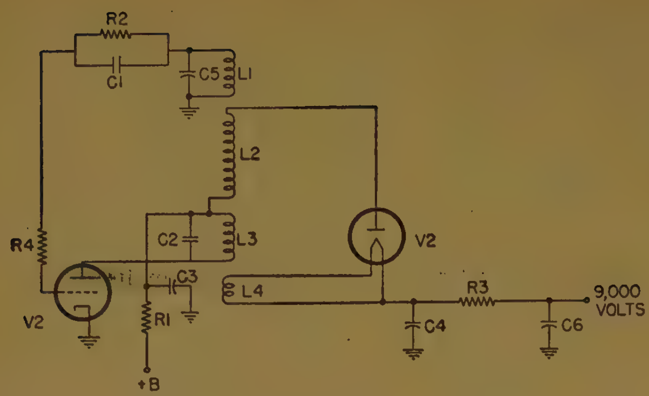


Figure 5. Schematic circuit diagram of high voltage power supply

mechanism with a range from 44 to 216 megacycles. These have the advantage of not requiring a switch, but have the disadvantage of tuning over a large portion of the radio spectrum wherein there are no stations, and thus restricting the usable portions of the scale. Also, positioning accuracy requirements are quite stringent.

A distinct advantage of using separate coils for each channel is that the selectivity of each channel can be controlled to the extent needed. Selectivity requirements may be different for some channels than for others. For instance, using the standard Radio Manufacturers' Association intermediate frequency it is possible for high powered frequency modulation stations in the band from 88 to 108 megacycles to lie on the image frequency of television channels 1 and 2. When individual coils are used for each channel this problem is readily solved by increasing the selectivity of these two channels to the degree needed.

SYNCHRONIZATION

Another circuit of particular interest in many new television receivers is the automatic frequency control synchronization for horizontal scanning circuits. The use of this circuit eliminates the characteristic scalloped-edge effect so typical of prewar receivers.

In brief the circuit operates by utilizing a direct voltage derived from the average frequency of the horizontal synchronizing pulses for controlling the frequency of the line scan oscillator. This average frequency is not disturbed to any appreciable affect by scattered bursts of noise and therefore the receiver maintains excellent synchronization right through the noise.

INTERMEDIATE FREQUENCIES

With new and higher frequency allocations for television it became necessary to change the intermediate frequencies used in receivers. Prewar intermediate frequencies usually lay in the region from 8 to 12 megacycles, but most modern receivers have an intermediate frequency considerably higher. The Radio Manufacturers' Association has standardized on an intermediate frequency such that the sound carrier lies between 21.25 and 21.9 megacycles, and the picture carrier between 25.75 and 26.4 megacycles. This obviates a lot of difficulties encountered with the old prewar intermediate frequencies such as interference from high powered short wave transmitters and poor image rejection. It also helps in the problem of reducing local oscillator radiation.

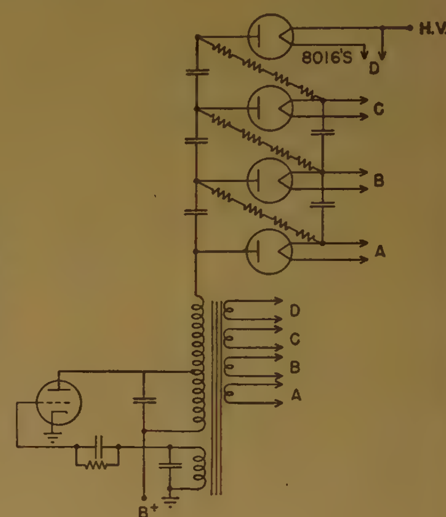


Figure 6. Schematic circuit diagram of high voltage power supply with voltage multiplier

OPTICAL SYSTEMS FOR PROJECTION RECEIVERS

The most popular type of optical system in use in projection receivers today is a reflective system known as

Figure 7. High voltage power supply of Figure 6

the Schmidt system. Figure 8 shows the essential elements of a Schmidt system. It can be seen that light from the picture which is formed on the face of the picture tube is collected by the spherical mirror and reflected back to focus on the picture screen. In the process the light passes through the aspheric corrector lens which corrects for spherical aberration of the spherical mirror, and is turned at right angles by the flat mirror set at 45 degrees. Picture sizes of 16 by $21^1/_8$ inches commonly are used although larger ones are possible. The Schmidt system is characterized by its simplicity and its high light efficiency. Apertures equivalent to approximately *f*0.9 are attainable.

Some refractive systems are being used in projection receivers. Here a lens system similar to that in the ordinary picture projector is used to collect light from the picture tube face and focus it on the picture screen. To date refractive systems have suffered by comparison to the Schmidt because they have a smaller effective aperture, thus giving a picture which is less bright. Also they result in barrel distortion when used with the standard projection tube. (The projection tube has a convex face although the refractive system requires a flat face, or ideally a concave face tube.) Attempts made to eliminate this distortion by the use of field flattening lenses have not been entirely successful. Undoubtedly a suitable tube can be developed and produced when the refractive system is developed to the point where it will be equivalent to the Schmidt reflective system in cost and performance.

INTERCARRIER SOUND SYSTEM

In past and present television receivers the sound signal is received, amplified, and heterodyned by the same radio-frequency circuits and tube employed for the picture signal. The sound signal ordinarily then is separated from the video signal early in the video intermediate-frequency stages. It then is amplified in its own intermediate-frequency channel and detected.

In the intercarrier sound system as recently proposed by R. B. Dome, however, the sound signal is not separated from the video signal in the intermediate-frequency channel at all. Instead, both the sound carrier and the picture carrier are allowed to be detected in the second video detector. These two carriers beat together to produce a 4.5-megacycle beat note. This 4.5-megacycle beat note will be frequency modulated with the audio-frequency modulation of the original sound carrier.

This 4.5-megacycle carrier is separated conveniently from the video signal at the input to the picture tube. It then is amplified, limited, and detected as is a conventional frequency-modulation signal. Figure 9 shows a block diagram of the system.

ADVANTAGE OF SYSTEM

The chief advantage of this system is that the exacting requirements of local oscillator stability are largely removed because the 4.5-megacycle carrier is independent of the local oscillator frequency and is dependent only on the stability of the two carrier frequencies as radiated by the television transmitters, and these, of course, are crystal controlled. Thus it is necessary only

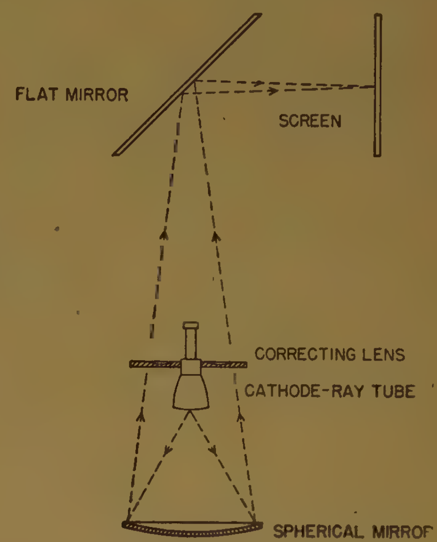


Figure 8. Elements of the Schmidt reflective system

to have a stable 4.5-megacycle discriminator and channel.

To the receiver owner the foregoing means that objectionable drift of the receiver, which sometimes makes retuning necessary, practically is eliminated.

For best operation some minor additional requirements are placed on the transmitter. One of these requirements is that there be no frequency or phase modulation of the picture carrier. Another is that the picture carrier

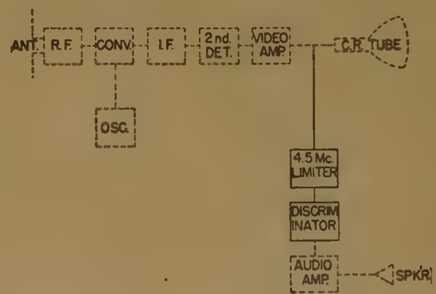


Figure 9. Block diagram of the interchannel sound system

not be allowed to drop to zero at any time, even when transmitting white. Standards for these items are being sponsored by the Radio Manufacturers' Association, and when they finally are adopted by the Federal Communications Commission and industry then the intercarrier sound system likely may be incorporated in most receivers. It appears that such standards will be adopted soon.

Of course the adoption of these additional standards will in no way cause obsolescence of present day receivers.

1946 Edison Medal Presentation

PRESENTATION of the 1946 Edison Medal to Lee de Forest (F '18) "for pioneering achievements in radio and for the invention of a grid-controlled vacuum tube with its profound technical and social consequences" was made by AIEE President J. Elmer Housley on Tuesday, January 27, at a general session of the 1947 AIEE winter meeting. David Sarnoff (M '23) introduced the medalist. The history of the medal itself was given in *ELECTRICAL ENGINEERING* for February 1947, page 122.

Lee de Forest

DAVID SARNOFF
MEMBER AIEE

DESTINY has an ingenious way of staging the drama of progress through science, for seldom are the actors gathered together and rehearsed. Each plays his part when time and opportunity give the cue. We find that new ideas are born at unexpected moments, in unusual places, and by unsuspected genius. Radio is a good example that reveals how science and fate join in extending the cavalcade of man's progress in art, science, and industry.

Let us recall a particular case—an act in the drama of radio science that is especially appropriate on this occasion. In America, a farm boy named Thomas Alva Edison was born 100 years ago, destined to discover an electric lamp to light the world. On the other side of the Atlantic, in England, another boy—John Ambrose Fleming—was born two years later, and as a young man his fascination with electricity and wireless led him to study the Edison lamp.

Something whispered to Fleming that it might possess unique possibilities as a detector of wireless waves. He had read of the mysterious effect of electrons at play within the glass bulb of Edison's lamp. He wondered if those electrons might be harnessed to make the lamp act as a valve to control the flow of a radio circuit, in much the same way as a valve serves in a water pipe. He ardently pursued the idea, and as a result he invented the Fleming valve which we call a "tube." It was the first electronic detector of wireless signals.

BIRTH OF DE FOREST

The scene shifts back to America. At Council Bluffs, Iowa, on August 26, 1873—26 years after the birth of Edison—a boy was born and named Lee de Forest. He was "cut out in his father's hopes" to be a minister. But he turned instead to science. He went to Yale University, as his father had done. But at New Haven the pathways of their careers diverged sharply. Young de Forest heard Professor Henry Bumstead lecture on electromagnetic waves and watched him demonstrate the Hertz experiments. From that day on, Lee de Forest had wireless in his blood, and, I surmise, some electrons too!

Naturally, he read everything he could find on the subject, and everything he read fired his fertile imagination. He was enthralled by the achievements of Marconi. He learned how Fleming had invented the valve detector, but this device would not amplify the current it controlled. What the valve detector needed, so it seemed to de Forest, was a device to control the local currents that were induced by the incoming wireless waves. So in 1906, 40 years ago, de Forest added a third element to the valve by inserting a zigzag piece of platinum wire between the filament and plate. He called it a "trigger," or "grid," and named the new 3-element tube the Audion. It is a generator of Hertzian waves, as well as a detector and amplifier of these ethereal, wireless messengers. The electron tube now is recognized as one of the 20 great inventions of all time.

At the birth of the Audion, de Forest predicted its future in these words: "Little imagination is required to depict new developments in radiotelephone communications, all of which have lain fallow heretofore, waiting for a simple lamp by which one can speak instead of read."

But the electron tube far has surpassed that early-day prediction. Radio learned to talk and to sing. And the invention of the young man who did not follow his father into the pulpit has made, perhaps, an even greater contribution in spreading the gospel to the far corners of the earth.

USES OF ELECTRON TUBES

Because of their versatility, we find millions of electron tubes at work throughout the world. They are used in electrical communications and signaling, with or without wires. Modern telegraphy, telephony, radio, motion pictures, phonographs, transportation, navigation, aviation, and hundreds of industrial operations now employ de Forest's basic invention. It is a significant fact that this invention has withstood the test of time over a period of 40 years and that it still continues to enlarge its field of usefulness.

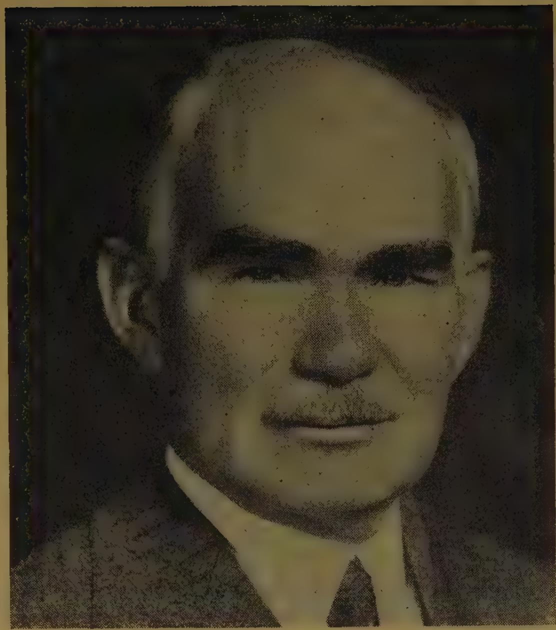
Electron tubes also were a key to victory in the war. Without them, many devices that helped to defeat the enemy might not have been available. Today these

---

Full texts of the speech of introduction made by General Sarnoff and the speech of acceptance by Doctor de Forest.

David Sarnoff is president of the Radio Corporation of America, New York, N. Y.

tubes are one of the hopes for the attainment of peace through freedom to listen, and thereby to achievement of a better understanding between the peoples on this earth. Statesman or peasant has but to snap a little switch, and the electron tube pulses with the pulse of the entire world.



There would not be time enough in all this afternoon to evaluate the universal triumphs of the modern electron tube. Our purpose today is to honor the man who, through his invention of the Audion, made an important contribution to science and society. It has been my privilege to have known him for many years, and it is indeed a pleasure to see him here today. He has crossed the threshold of three score and ten, but he still has the same faith in the future and the same spirit of pioneering that always have characterized him.

I am honored to present on behalf of the American Institute of Electrical Engineers, the 1946 Edison Medalist, Doctor Lee de Forest, who will receive this high award "for pioneering achievement in radio and for the invention of the grid-controlled vacuum tube with its profound technical and social consequences."

The Audion

LEE de FOREST
FELLOW AIEE

IN MY YOUTH I learned a Bible verse which read, "If ye have faith, all these things shall be added unto thee," which in my case I found should be supplemented thus—"faith, plus longevity!" The laurel is better late than posthumous!

I am happy, indeed, today to be so fortunate as to have lived to realize one prize to which I had long aspired, the great honor which your committee has bestowed upon me, the Edison Medal.

From early boyhood, Thomas A. Edison was my ideal, my living inspiration, my idol. My ever-present ambition was to be able to achieve something, sometime, which might be compared with his incandescent lamp or his phonograph, a thing revolutionary in nature, applicable to the needs of a continually unfolding, ever-developing society.

Commencing almost with the beginning of the wireless telegraph, I sought to apply to that new enterprise my newly acquired knowledge of Hertzian waves, their generation, and reception. Because I had to build my own equipment, I, perforce, concentrated on a new wireless detector, for it was cheap to construct, and for experiment.

EVOLUTION OF THE AUDION TUBE

Almost at the start, a lucky observation of a gas burner which fluttered in accordance with signals from my small spark gap led my thinking into a channel as different as possible from that of the responder on which I was then at work. Although the observed action proved to be wholly acoustic and not electromagnetic, I became firmly convinced that the Hertzian waves, or their derived currents, could be made to affect the conductivity of gases, with electrodes heated to incandescence therein. Three years later I proved that my idea was well founded when wireless telegraph signals were received with a Bunsen burner detector having in its flame two platinum electrodes, one of them incandescent. A slow evolution from this stage brought me, in 1906, to the so-called Audion, described in a paper presented that summer before a New York session of the Institute (The Audion. AIEE *TRANSACTIONS*, volume 25, 1906, pages 735–63.)

In the "flame responder," the hotter electrode was connected to the negative terminal of a 6-volt dry battery and to earth. The positive battery terminal led to a telephone receiver, from the other terminal of which a wire led to the second electrode located in the flame. To this terminal also was connected the receiving antenna. Through all this work I, naturally enough, was seeking to create a genuine relay—a trigger device, whereby the weak incoming signal could control the flow of a local battery current of relatively vastly greater power.

Consequently, when I later heated my cathode and enveloping gas electrically, as by employing a small carbon filament sealed in a partially evacuated glass vessel—a great step in refinement from the open flame—I still employed that other essential element of my first devices, the anode, or *B*, battery.

In the summer of 1906, the Audion (as my assistant, Babcock, cleverly named it) embodied, in a glass

---

Lee de Forest is founder and president of the Lee de Forest Laboratories, Inc., Los Angeles, Calif., and also at present is associated with the American Television Laboratories, Chicago, Ill.

envelope, the elements of the flame detector, heated cathode, relatively cold anode, local battery, and signal indicator. The control electrode was added next, first in the simple form of a strip of tin foil wrapped around the tube. This was primarily to increase the sensitivity of the device by preventing any shunting of the received energy through the anode-to-earth path. Prior to that, the antenna lead, or its equivalent, had been connected directly to the anode.

CONTROL ELECTRODE

This crude control electrode proved a definite improvement. Successive steps in increasing sensitivity of this new detector: placing the control electrode in the form of a plate, like the anode, within the envelope, but on the opposite side of the filament cathode; next locating this electrode between the cathode and anode in form of a perforated plate; and finally, for simplicity of construction, the addition of a short piece of platinum or nickel wire bent in the form of a grid. This last step was late in 1906.

During that year my various models were constructed and pumped by William McCandless, maker of miniature lamps, whose kindly sympathy was a definite essential to my groping progress. His were mechanical pumps only, so that my anode voltages during this epoch were necessarily low—of the order of 15 to 22 volts. Through all this work, the writings of J. J. Thompson were my Bible—and constantly were consulted.

The Audion, until 1912, remained only a detector of wireless signals, happily by far the most sensitive detector existent, as proved by the ever-increasing eagerness of the then "hams" to acquire one of these coveted bulbs, by hook, crook—or purchase, if need be—at a fabulous cost of $8, with filament life unguaranteed, but hopefully of the order of 30 hours!

From time to time the statement has appeared that in my invention I contributed the grid to a rectifier tube, or valve, and thereby created the Audion or the 3-electrode tube, the present heart and soul of radio communication. What could be more simple in the way of an explanation? What at the same time further from the truth, and still further from a knowledge of the simple facts of electronic principles?

To recognize that the anode voltage is as essential a feature of the Audion as is the third electrode, that by virtue of this local energy alone is the Audion a relay device, and therefore an amplifier of transcendent value, instead of a mere rectifier of received alternating currents—seems to be so self-apparent, that I always have been at a loss to understand why anyone should fail to grasp it. Yet such is the very common position of many writers: "The Audion is the Fleming valve with a third electrode." "Its inventor improved the valve merely by the addition of the grid."

Add a third, or any number of electrodes to the simple diode, and it remains a valve—a mere rectifier, possessing the utility of the rectifier, and nothing more.

The evolution of the Audion patent claims marks, in a general but incontestable manner, the evolution of the Audion; first it was a gas effect in the open air, then in an enclosed vessel, then in an exhausted vessel, exhausted like an incandescent lamp, then to higher and higher degrees of vacuua (as early as 1912 I employed an "X-ray" vacuum). But always it was a relay. Always the *B* battery was employed. The control electrode idea preceded even the enclosed vessel. And never at any time was the Audion "the Fleming valve with merely a grid added."

It was by the devious path just outlined, that I finally arrived at the grid-controlled amplifier.

APPLICATION IN TELEPHONE FIELD

In October 1912, having developed the Audion amplifier as far as was feasible with the resources at my command, I asked my good friend John Stone to bring to the attention of the Western Electric engineers the possibility of using this amplifier in their long-distance lines, and particularly in the transcontinental service which they were asked to install between New York and San Francisco against the opening of the Panama–Pacific Exposition. At the invitation of Doctor Frank Jewett I proceeded to demonstrate to his engineers the 3-stage Audion amplifier. The potentialities of this new device for telephone needs was appreciated immediately by the Telephone Company, and the task of further developing the tube for long-lines communication was given to Doctor H. D. Arnold. So skillfully did Doctor Arnold and his staff undertake the further refinement of the amplifier tube, that within two years transcontinental telephone service was established. The zeal and rare understanding of the elements of the problem, with which that staff of trained men developed the amplifier and applied it to the long-sought transcontinental telephone line, stand unique in the annals of brilliant achievement in electrical engineering. Too much credit cannot be given to the engineers and scientists of the Bell System for the splendid manner in which the tube, both as amplifier and as oscillator, generator of alternating currents of almost any frequency, has been developed and refined, since its initial presentation to them. Within three years thereafter the human voice had spanned the Atlantic!

Following the close of the first World War, I resumed my early broadcasting work, using the oscillator tube at the transmitter and the Audion detector and amplifier at the receiver. With these three necessary components so well developed at that time, the possibilities of the radiobroadcast began to be appreciated by various commercial agencies, and with such zest that during the 1920's a new major industry attained maturity, demonstrating its unlimited possibilities, commercially and culturally, fittingly to be described as an "expanding

universe," an instrumentality which has been compared justly with the invention of printing.

The magnitude of the magic of this thing of broadcasting came overwhelmingly upon me one day when, motoring through the California mountains, I listened to grand opera being sung at that instant in Moscow, Russia. Today any one of us can be witness to a similar miracle, due primarily to the ability of a chain of small evacuated tubes to amplify by a billion times, the inconceivably minute energy received from small transmitting stations, located, if you please, at the antipodes.

The electron emerged from the university laboratory briefly before the beginning of the century. Its application to the service of man dates from the first knowledge of how to control its migrations through *vacuo*. Starting with that discovery, the utility of this new physical tool has accelerated so amazingly that the first half of our century is fittingly termed, "The Electronic Age."

Lee de Forest and AIEE President Housley at the presentation ceremonies

From such humble tasks as control of a drinking fountain, to transmitting a signal to our moon and return, even to those involved in the process of the cyclotron, where the foundation stones of our universe are shattered, scarcely a phase of activity in science, technology, or medicine has failed to demand essential aid from the vacuum electron.

USE IN OTHER FIELDS

In fields other than the telephone, early outstanding work in research and invention was undertaken by engineers of the Radio Corporation of America, notably in that of radio communication, and in the production of receiver–amplifier tubes of multitudinous forms and in astronomical quantities; by the General Electric Company in giant power tube design; by the Westinghouse Company in its application to a hundred industrial uses.

Outstanding names among many early leaders in electron investigation since 1912 are Pierce, Chaffee, and Zworykin, that genius who wedded the Iconoscope to the grid amplifier to give television to the world.

Following the first World War, every large electrical corporation in Europe began intensive development of the tube for every possible application; and World War II incited to keenest research hundreds of competent laboratories, the combined knowledge and skill of which in four years advanced the electronic age further than 20 years of development in peace could have.

Following world communication and broadcasting, the tube with its manifold circuits has produced the talking picture; the living reproduction of recorded music; and television—gigantic new industries, now, or soon to be.

In addition to its colossal aid in winning the war, as by radar and the proximity fuse, the freed electron in peace has afforded new employment to millions, and has enriched the lives of hundreds of millions, hitherto dull and straitly confined.

Here in glass and metal lies the control of the world's greatest force, the electron. Here is man's eye to see through solids, beyond horizons, and to behold the infinitesimal, to make audible the inaudible, his voice heard around the world, his mastery of time, temperature, and motion.

ROLE IN SAFETY

In the electron tube lies the safety of all who fly, making possible today's crowded aviation; the tube which now stands mutely asking leave to end collision, by water, air, and rail; there being lacking only sufficient of man's humanity to man to put it, generally and intensively, to that merciful job.

Time is not afforded to catalog even a small fraction of the useful applications of this tube in every imaginable field of man's activity, commercial or spiritual, which during the past 25 years have been achieved; nor is my imagination equal to the prophecy of what new wonders will this Aladdin's lamp illumine for the world, during the remainder of our century. I count myself most fortunate among men to have been granted to live to see this gigantic unfolding of an implement, and an idea, which first came to me more than 40 years ago.

1946 Hoover Medal Presentation

Presentation of the Hoover Medal for 1946 to Doctor Vannevar Bush, (F '24) president of the Carnegie Institution of Washington, was made January 30, at a general session of the AIEE winter meeting. Established in 1930 through a trust fund created by the gift of Conrad N. Lauer, the Hoover Medal is awarded periodically by a board of award composed of representatives of the national societies of civil, electrical, mechanical, and mining engineers "to a fellow engineer for distinguished public service." The first award was made in 1930 to former President Herbert Hoover.

Scott Turner, president of the Hoover Medal Board of Award, presided and made the 1946 presentation. E. L. Moreland (F'21) summarized the medalist's career.

The Hoover Medalist

EDWARD L. MORELAND
FELLOW AIEE

IN VIEW OF THE DIFFICULTY a great many of you have with the given name of our medalist, I am, before starting my more formal talk, going to quote part of an introduction of Doctor Bush by Doctor G. R. Harrison, dean of science at Massachusetts Institute of Technology.

> 'Tis said that Bush, before the war,
> Was often know as Vanney Var,
> Though persons every bit as clever
> Were prone to hail him as Van Never.
> Yet who shall call those ev'n naiver
> Who introduce him a Van Neaver?
>
> All this despite the fact that he
> Signs letters with a simple "V."
> When Bush adds more it causes trouble
> For all is indecipherable.
>
> Van Never, Neaver, Vanney Var,
> Whichever of these three you are,
> Do not despise the cautious man
> Who hails you forth as simply Van!

The terms of gift of the Hoover Medal specify that it is to be awarded periodically by a Board of Award composed of representatives of the four Founder Societies "to a fellow engineer for distinguished public service." Certainly no argument is needed before this audience to show that Vannevar Bush amply meets these terms and is a worthy companion to the men who have preceded him as Hoover Medalists.

Let us look for a moment at only one of the attainments of our medalist as an engineer. I do not here cite the full range of the applications of his inventive genius, that run from peripatetic turkey houses to typewriters that all but talk. Rather, I mention his inspired development of the differential analyzer in the late 1920's which, coming nearer culmination in the electronic version completed at about the time of the outbreak of war, was at work day and night through the war years on problems vital to the defense of the nation. If engineering is rightly held to be the useful application of scientific knowledge, then in this great instrument Doctor Bush has made an engineering accomplishment of the first order.

In honoring him today at this ceremony, we make acknowledgment of his engineering genius, not alone as it is embodied physically in this instrument, but primarily as it is expressed philosophically in the fundamental purpose that impels him. That purpose, which runs through the entire body of his work, and which becomes of more crucial significance with every day's advance of our complex civilization, is to apply physical means to reduce the burden of computation, calculation, and repetitive routine on man's mind and thus to free his intelligence for creative effort in the faith that knowing is hazardous—and well worth the risk.

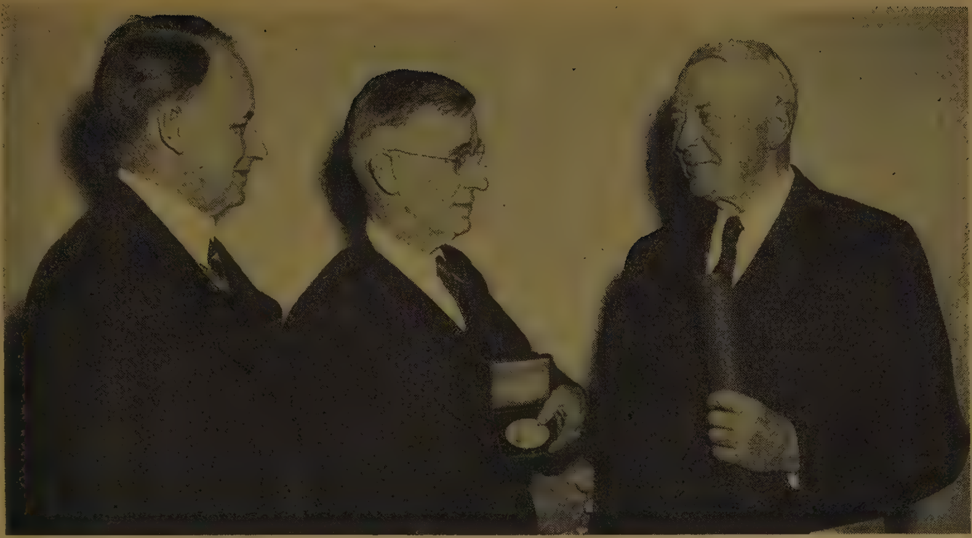
At different stages in the course of Doctor Bush's following of this purpose, recognition has been made by his colleagues. The first such was the award of the Louis Edward Levy Medal by the Franklin Institute in 1928. Seven years later the AIEE presented to him the Lamme Medal, and in 1943 he received the Edison Medal of the AIEE and the Holley Medal of the American Society of Mechanical Engineers. I mention these few from among many marks of understanding of his work, because they are indicative that its long-range importance was comprehended early and that its progress has been considered of noteworthy import.

The titles that men bear are at best but rough characterizations; nevertheless, as we turn to consider the medalist as a public servant, we shall find them a useful starting point. In private life Doctor Bush is president of the Carnegie Institution of Washington, a great privately endowed research organization dedicated to work for the public good. In his public life he has held many posts of distinction; for example, he has served at one time or another as chairman of the National Advisory Committee for Aeronautics, chairman of the National Defense Research Committee, director of the Office of Scientific Research and Development, chairman of the Joint New Weapons Committee of the Joint Chiefs of Staff, and now chairman of the Joint Research and Development Board of the War and Navy Departments.

Doctor Bush's first great service in our recent war effort, and perhaps the most far-reaching in its effect on

Full text of Mr. Moreland's address introducing the medalist.

Edward L. Moreland is executive vice-president of Massachusetts Institute of Technology, Cambridge, Mass.



Mr. Moreland, Doctor Bush, and Mr. Turner after the Hoover Medal presentation

the war, was in early arousing President Roosevelt to the urgent necessity of marshaling science to defend the nation by co-ordinated attack on the scientific problems of modern warfare. This foresight by Doctor Bush led logically to his being called to pioneer the initial effort and his being entrusted with greater and greater responsibilities for the direction and co-ordination throughout the war of the greatest planned collaboration of scientists, engineers, industrialists, and military men the world has ever seen. The effectiveness of the endeavor summed up in the letters "OSRD" is clear in the record of the war.

The creative work of the OSRD now is completed. The work of the Joint Research and Development Board of the War and Navy Departments is just beginning. The duty of this board is to stimulate forward-looking research and needed developments, to reconcile divergent opinions, to resolve differences, to work for the elimination of overlapping and duplication in research programs, and to assess and evaluate objectives and the means designed for achieving them. In short, the duty of the JRDB is to foster efficiency and vision in the vital research efforts of the military establishment of the nation in the years ahead. The dimensions of that effort are the clearest recognition of the major position which science and engineering have come to occupy in the national life. Again Doctor Bush is asked to carry the burden of the chairmanship of this new board. To this he has brought not only his keen judgment of issues and clear understanding of men but also the invaluable experience of his wartime work, with all its ramifications from penicillin and surgical techniques to proximity fuses and the atomic bomb.

More than that, he exercises afresh in these present tasks a quality most rare among men—the quality which is the fundamental reason for the award which is being made today. This is the earnest and constant searching and weighing of facts and alternatives in the effort to determine where the public good lies, and how it may be served best. This quality of his thinking, epitomized from one aspect in his memorable report to the President, "Science, the Endless Frontier," in his service on the Acheson Committee in the formation of American policy on atomic energy, and in his unremitting and unselfish contributions through testimony, advice, and counsel to the formulation of sound legislation; and appearing from another aspect in his public papers and addresses, is the hallmark of the sincere mind, and of the citizen who feels an honest obligation not simply to yield up passively but rather to contribute actively to the full extent of his resources to the commonweal.

I am honored to acclaim Vannevar Bush as such a citizen, recipient of the Hoover Medal for 1946.

The Promises of Peace

VANNEVAR BUSH
FELLOW AIEE

I ACCEPT THE HOOVER MEDAL for 1946 with a deep feeling of gratefulness and pleasure. Let me say that in accepting it I regard it as in the larger measure a symbol of your recognition and salute to the able and unselfish men with whom it has been my rare privilege to be joined in collaboration and partnership in these recent years.

An occasion such as this is the more welcome to thoughtful men, because it gives opportunity to step aside for a moment from the rush of the days, to view in retrospect what we have learned from the emergency now past, and to consider how those lessons best may be applied as we work for the solution of the great problems inescapable in the endeavor to make peace and good will secure among men.

For one thing, we have learned—or, better, have confirmed again our knowledge—that, when free men nurtured in the democratic tradition join together in voluntary collaboration in the face of dire peril, when they sink their minor differences and honestly resolve major

Full text of Doctor Bush's address after the presentation of the Hoover Medal.

Vannevar Bush is president of the Carnegie Institution of Washington, Washington, D. C., and head of the Joint Research and Development Board of the War and Navy Departments of the United States.

ones, when each contributes to the common cause the vigorous initiative and the particular skills which are his by virtue of the tradition of freedom in which he has grown, the result is a controlled and concentrated strength that no opponent can withstand. Thus it is that, when democracy voluntarily girds itself with rigid controls for war, the most ruthless totalitarianism in human history cannot stand against it, and the most inhuman aggression and brutality must yield before it. The might of democracy does not reside, however, in its voluntarily self-imposed wartime marshaling and focusing of its powers, but rather in the heritage of freedom for initiative, enterprise, and self-development whence those powers rise.

Hoover Medalists

1930	**Herbert Hoover**
1936	**Ambrose Swasey**
1938	**John F. Stevens**
1939	**Gano Dunn**
1941	**D. Robert Yarnall**
1942	**Gerard Swope**
1944	**Ralph E. Flanders**
1945	**William H. Harrison**
1946	**Vannevar Bush**

Again of outstanding significance, we have learned the centrality and the swift pace of science and technology in the modern world. This lesson in its simplest terms was spelled out in the fact that the outcome of a great war now can be determined by the evolution of weapons which at the outbreak of hostilities were unknown. But these are merely the simplest terms. The lesson has a vastly broader meaning. Though we cannot now hope to sense its full implications, we already can perceive that out of basic research into the natural sciences, honestly and courageously pursued, and out of the imaginative and pioneering application of its findings through applied science and its consequence, engineering and technology, we can achieve a command over nature, a control of our environment, which will make the conditions of human life on this planet better, more gentle, more kindly, than man ever had dreamed. In a dozen fields—in the control of disease, in the ready filling and maintaining of abundant food stocks, in swifter and ever more dependable interchange whether of thought, or men, or things, in the lightening of the burden of labor, in the provision of richer preparation and more varied means for the enjoyment of freedom of the mind and the spirit, in the enhancement of the intelligence and the prolongation of the life span in which man may rejoice in exercising it—prospects vast and high lie before us. To sum it up, our opportunities in the application of intelligence to the betterment of life are at the most promising point ever known.

As we look to the future, of one truth we can be sure. To bring to realization these great promises, which we now can discern, we must have a degree of reasoned courage and joint endeavor surpassing anything we have attained thus far. We must have this spirit not merely in individual national terms. We must have it on a world scale. Toward this accomplishment the nations of the world already have made great and heartening progress. Here at home in the United States, we already have gone far toward the establishment of a pattern of the relationship between government and science which can be counted on to contribute knowledge and strength in the international approach to a comparable end. The course is not an easy one, in anybody's terms; for we, are still, throughout the world, shaken in the aftermath of a great struggle, and we have yet to learn the secret of perpetuating in the peace that mutual confidence and common endeavor which joined us in strong partnership against the forces of aggression. The great American whose name this medal bears put the problem in these words only a few years ago, in discussing the American Bill of Rights.

"Even in America," he said, "where liberty blazed brightest and by its glow shed light on all the others, liberty is not only besieged from without but it is challenged from within. Many, in honest belief, hold that we cannot longer accommodate the growth of science, technology, and mechanical power to the Bill of Rights. But, men's inventions cannot be of more value than men themselves."

Mr. Hoover said further, "Those who proclaim that the machine age created an irreconcilable conflict in which liberty must be sacrificed should not forget the battles for these rights over the centuries; for let it be remembered that in the end these are undying principles which spring from the souls of men. We imagine conflict not because the principles of liberty are unworkable in a machine age, but because we have not worked them conscientiously or have forgotten their true meaning."

I borrow one more thought from him: "The dynamic forces which sustain economic security and progress in human comfort lie deep below the surface. They reach to those human impulses which are watered alone by freedom . . . From the release of the spirit, the initiative, the co-operation, and the courage of men, which alone come from these freedoms, has been builded this very machine age with all its additions of comfort, its reductions of sweat."

It is in the spirit of this analysis that we must go forward, bringing to the solution of the problems that beset the world in the relations between peoples the same kind of forthright intellectual honesty essential to the solution of problems in science, drawing from the inescapable lessons of the physical world a rigor and an ethic that will serve us well in learning and evaluating the lessons of human relationships. Through the voluntary collaboration of men of good will, we have sure hope of attaining the betterment of life for all men throughout the world.

L. W. Chubb—1947 John Fritz Medalist

THE JOHN FRITZ MEDAL for 1947 was awarded on January 29, 1947, to Doctor Lewis Warrington Chubb (F'21) for "pioneering genius and notable achievements during a long career devoted to the scientific advancement of the production and utilization of electrical energy." The presentation took place during the AIEE 1947 winter meeting, New York, N. Y., at a general session presided over by Malcolm Pirnie, member of the board of award. The medal was presented to Doctor Chubb by N. E. Funk (F'34) chairman of the board of award.

The John Fritz Medal is awarded annually by a board composed of four representatives of each of the four national engineering societies, the AIEE, the American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Society of Civil Engineers, for notable scientific or industrial achievements, regardless of nationality or sex. It was established to perpetuate the memory of the achievements of John Fritz, a pioneer in the iron and steel industry, and the first award was made to Mr. Fritz on August 21, 1902, his 80th birthday. It has been awarded each year since 1905.

Full text of the address by M. W. Smith (F'42) describing the medalist's career, and Doctor Chubb's acceptance follow.

The John Fritz Medalist

M. W. SMITH
FELLOW AIEE

The selection of Doctor Lewis Warrington Chubb to receive the John Fritz Medal is indeed a fitting testimonial to this pioneering scientist whose 40 years in research and engineering have coincided with the period of greatest growth of the electrical industry.

Today he is being honored for "pioneering genius and notable achievements during a long career devoted to the scientific advancement of the production and utilization of electrical energy." The aptness of this citation is reflected in the comments of a colleague who once said:

"A uniform characteristic of Doctor Chubb's work has been its pioneering quality. Again and again he has opened up a subject or field in which subsequently many workers have labored for many years. Much of the significance of Doctor Chubb's work became evident in practical engineering achievement 10, 20, or even 30 years after his far-seeing initiating endeavor. Under the stimulus of his lively imagination, ideas would grow and take clearer and more concrete form. All who came to him went away richer in ideas and knowledge."

It is a real pleasure to have the opportunity on this occasion to give an account of Doctor Chubb's career and to signalize the important accomplishments for which we are honoring him today. Although this is a very pleasant task, I find myself embarrassed by the breadth of Chubb's interests, his prolific inventiveness, and the intensity of the activity of his scientific mind. In the limited time available I can give only a very brief story, hardly more than a catalogue of his achievements.

Doctor Chubb, the son of Colonel Charles St. John Chubb, was born on October 22, 1882, at Fort Yates, Dakota Territory, where he spent his boyhood days on various army posts.

After being graduated from Ohio State University in 1905 with the degree of "mechanical engineer in electrical engineering," he joined the Westinghouse company, thus starting the career we now are honoring.

FIRST GREAT CONTRIBUTION

Chubb's first great contribution was with respect to magnetic materials. At that time, open-hearth low-carbon sheet steel was used in the cores of electric machines. Expected iron losses were high but measured losses were much higher than expected, 100 per cent or more. Chubb located the various sources of these losses. Magnetic cores which were shaped improperly and gave harmonic fluxes were replaced by those of proper design. Unfortunately-placed rivets and the host of other apparently trivial contributors to losses in the early machines were ferreted out and made impotent.

He was the first to recognize the effect of punching strains in impairing the quality of magnetic materials and the first to practice annealing in an inert atmosphere. Likewise, about 1908, he discovered the effect of rolling processes in producing directional effects on the hysteresis and permeability of silicone sheet steel. Chubb capitalized on this knowledge by developing a line of laminated cores for distribution transformers having L shaped punchings with both legs cut from the sheet at 45 degrees to the rolling direction, giving the best quality and minimum of scrap material. These transformers were without rival in quality and economy and required no redesign for many years. He was among the first to recog-

---

Full text of an address delivered at the John Fritz Medal presentation ceremony, January 29, 1947, during the AIEE winter meeting in New York, N. Y.

M. W. Smith is vice-president in charge of engineering, Westinghouse Electric Corporation, Pittsburgh, Pa.

L. W. Chubb (left) receives the John Fritz Medal from N. E. Funk

the harmonic analyzer and the polar oscillograph are specific examples. His telephone interference factor meter (*TIF* meter) still is used generally today.

The pioneering nature of Chubb's work is illustrated well by his invention and development of amazing new artificially-formed light polarizing substances. He foresaw the myriad applications of polarized light in peace and war, at a time when polarized light was only a laboratory tool for very special tests and measurements.

As his responsibilities in guiding others increased, Chubb was able to spend only limited time on inventions of his own. But he always had something "on the fire." He now has more than 150 patents to his credit. The latest one, covering an improved recognition light developed for the Armed Forces, was granted in August 1946.

Shortly after World War I, radio began to come into commercial prominence. In the forefront of this young industry was Chubb, who as a youngster had dabbled in this science. He became a member of the Westinghouse "committee of five," formed to investigate the possibilities of radio. In 1920, when there was a fight for supremacy in this new field, Chubb was chosen to guide the radio engineering activities of the Westinghouse company.

As radio grew over night from a scientific curiosity to an industry and a public service of entertainment, news, and international understanding, Chubb was among the few who guided broadcasting from the crystal set era into the mass production stage, with many technical advances and operational innovations.

nize the possibilities of iron-nickel alloys, and holds some of the earliest patents in this field.

Through these years the infant electrical industry was expanding rapidly, demanding new instruments, methods of design, fabrication, transmission, and control. It was a time when the horizons of industry were limited only by the inventiveness of the nation. In such a period Chubb's talents won quick recognition. In 1910 he extended his activites in engineering research and development, and six years later was placed in charge of all electrotechnical research for the Westinghouse organization.

One of the problems of those years was the limitation on the capacity of electric machines, then, as now, caused by the deterioration of insulation at high temperatures. Chubb moved to the attack with characteristic vigor, and made many important contributions in this field.

A problem repeatedly encountered in those days was that of making a mechanically and electrically good union between incompatible metals; for example, aluminum and copper. The basic method of using controlled short pulses of electric energy was devised by Chubb and is used widely today.

Early electric machines with their distorted wave shapes caused many difficulties such as telephone interference, resonant troubles, and circulating currents when paralleled. Chubb took great interest in these problems and solved many of them. The development of

OTHER HONORS

In 1933 the scope of Chubb's work won recognition from the University of Pittsburgh and Allegheny College. Both granted him the honorary degree of doctor of science for his outstanding achievements in electricity and associated sciences. The following year he was awarded the Lamme Medal at Ohio State University for "meritorious achievements in engineering."

During World War I, Doctor Chubb, as might have been expected, was extremely active in service of the United States, working as assistant to B. G. Lamme on the Naval Consulting Board. He contributed substantially to such projects as the development of submarine detection methods, improvements in gas masks, explosives, and numerous other undertakings.

In 1919 he represented the United States as a delegate to the International Electrotechnical Commission in London, England, and in March 1940 he was American delegate again when the commission met in Brussels, Belgium.

When World War II blazed across the United States,

path, men of Chubb's demonstrated talents were needed urgently. His reputation and widely known accomplishments caused him to be placed on numerous important committees such as the National Academy Uranium Committee, the Planning Board of the Office of Scientific Research and Development, the Special Committee for Jet Propulsion of the National Advisory Committee for Aeronautics, and the Advisory Board of the Office of the Quartermaster General. He was an official consultant for the OSRD, and directed many contracts for the development of weapons, defense systems, materials and processes.

Numerous technical conferences to which he contributed outstandingly and gave wise counsel based on his vast experience took much of Chubb's time. He was interested especially in the atomic bomb project. By personal work and sound advice in conferences he stimulated and advanced the work on the production of uranium metal, and in the developments for the separation of uranium isotopes including the electromagnetic separation methods, the mechanical centrifuge, the diffusion processes, and the ionic centrifuge.

In this short presentation I have had to omit most of Doctor Chubb's family history as well as many important events and achievements in his career, but a record of his professional accomplishments was published in a recent issue of *ELECTRICAL ENGINEERING* (*EE, Dec '46, p 583*). I cannot close, however, without speaking of the pleasure that his associates experience in their daily contacts with him. His warm interest and quick understanding make him easy to talk to. His unbounded optimism carries his fellow-workers through periods of discouragement so inherent in basic research, and his high appreciation of technical accomplishment makes it a joy to report and discuss work with him. As a representative of his colleagues, I am very happy to have the privilege, on this significant occasion, of paying a tribute to the life and work of our friend and associate.

New Age of Science

L. W. CHUBB
FELLOW AIEE

The award of the John Fritz Medal, established in memory of one of the most outstanding figures in the development of the iron and steel industry, and sponsored by the four founder engineering societies, is indeed an honor which I cherish deeply. On several occasions in past years while attending engineering conventions in this auditorium, I have witnessed the presentation of the John Fritz Medal to distinguished and deserving engineers and scientists whom I admired and envied.

My notification of the 1947 award of the medal was a great surprise and made me wonder why I should have been chosen for this great honor. Any achievements in the scientific advancement of the production and utilization of electric energy were the results of opportunities offered by the Westinghouse Electric Corporation with which I have been employed for over 40 years, by the many problems arising in the rapidly developing activities of the industry, and by the stimulation and co-operation of my many fine associates.

I recently received, from the board of award, a copy of the autobiography of John Fritz and have read it with considerable interest. His life and activity are both interesting and instructive. They certainly teach us that hard work and continuous effort are the keys to advancement. John Fritz had no formal technical education, for he started his career in 1838 before engineering courses existed in our colleges. His technical education was received through experience and self-study in the various branches of the iron and steel industry. The boy from the farm, starting as an apprentice blacksmith in 1838, worked his way up until he was an authority in almost every activity of the steel industry and had held the highest technical operating position.

John Fritz prepared himself for each promotion by observation and personal effort. While he was employed in one department during the day, at night he considered it a privilege to spend his time in another department observing operations, and I am sure, without demands for overtime or portal-to-portal pay.

This method of preparing himself for future positions seemed to have continued for a great many years. After he had learned all about one branch of the industry and had become promoted to superintendent, he would transfer to a new activity and repeat the process. Thus he became an authority successively in blacksmithing, puddling, blast furnace, bessemer, open hearth, forging, and other practices of the industry. He not only learned the going practice, but introduced many innovations which resulted in better quality, greater production, and economy.

We have learned from John Fritz' career that experience is a great teacher. It still is in all fields of technology. However, today engineering and science have expanded and become so complicated that the self-made man, unless a genius, no longer can expect to reach the top, know it all, or compete with the trained engineer or scientist having a thorough grounding in the physical sciences and fundamentals of engineering practice.

John Fritz was an outstanding leader of the machine age which has been with us for many decades. There is no slowing down, but rather an acceleration of the great technological advance through physics, chemistry, and all branches of engineering which promote the machine age development. Today, each worker has at his command several horsepower with which to fulfill the needs

Full text of an address delivered at the John Fritz Medal presentation ceremony, January 29, 1947, during the AIEE winter meeting in New York, N. Y.

L. W. Chubb is director of research, research laboratories, Westinghouse Electric Corporation, East Pittsburgh, Pa.

of man. With each year, except for war upsets and unfortunate artificial controls of our economy, our living conditions improve. New means of transportation and communication in effect have shrunk the world so that civilized peoples can have better commerce and international understanding—if they can forget their national jealousies and selfish motives.

The machine age has furnished the brawn. The enormous chemical industry, which became a factor in America after the first World War, has supplied many new materials; electronics, well established in the last two decades, has furnished the superhuman skills; and now nucleonics promises to add to the parade of progress.

John Fritz Medalists

1902	John Fritz	1926	Edward D. Adams
1905	Lord Kelvin	1927	Elmer A. Sperry
1906	George Westinghouse	1928	John J. Carty
		1929	Herbert Hoover
1907	Alexander Graham Bell	1930	Ralph Modjeski
		1931	Admiral David W. Taylor
1908	Thomas A. Edison		
1909	Charles T. Porter	1932	Michael I. Pupin
1910	Alfred Noble	1933	Daniel C. Jackling
1911	Sir William Henry White	1934	John Ripley Freeman
1912	Robert Woolston Hunt	1935	Frank J. Sprague
		1936	W. F. Durand
1914	John E. Sweet	1937	Arthur N. Talbot
1915	James Douglas	1938	Paul D. Merica
1916	Elihu Thomson	1939	Frank B. Jewett
1917	Henry Marion Howe	1940	C. F. Hirshfeld
		1941	Ralph Budd
1918	J. Waldo Smith	1942	Everette DeGolyer
1919	George W. Goethals	1943	Willis Rodney Whitney
1920	Orville Wright		
1921	Sir Robert Hadfield	1944	Charles Franklin Kettering
1922	Eugene Schneider		
1923	Guglielmo Marconi	1945	John L. Savage
1924	Ambrose Swasey	1946	Zay Jeffries
1925	John F. Stevens	1947	Lewis W. Chubb

The atomic age, or better, the nucleonic age, developing in the halls of science for many years and brought to reality by intensive wartime activity, is a step of supreme significance and seems destined to have a greater effect on our future civilization than the many comparatively minor yet revolutionary advances of the past. It is impossible to predict the changes which will come from nuclear science, the science which involves the transmutation of the chemical elements and confirms the equivalence and conversion between energy and matter. Nobody in Faraday's time predicted that electrical discharges in evacuated bottles and the later identification and evaluation of the electron would lead to the multibillion dollar electronic industry and give us radio, radar, X rays, fluorescent lights, and the marvelous electronic brains for control and regulation.

Already we visualize some possibilities of the atomic age—power and the means of using artificially produced radioactive materials to relieve the suffering of mankind. These however are only substitutes for fuel and radium, respectively. If history repeats and the civilized world has the wisdom to use the new potentialities for progress rather than self-destruction, we can look forward to the atomic age with new industries and most radical changes from this the most unusual step in scientific history

There seems to be no apparent end to the major scientific and technological advances. The machine age, engineering, electronics, chemistry, and other active fields of technology, continue to branch out and demand technically trained personnel and call for more and more specialization. The lessons learned during the late war show the great possibilities of applying scientific and engineering knowledge. We have, today, an enormous expansion of research and development to apply scientific and engineering knowledge to our peacetime pursuits. For the present year, budgets totaling more than a billion and a half dollars have been planned for industrial, governmental, and college research.

During the war, and quite contrary to the usual opinions, fundamental research, an important source of our great engineering progress, suffered greatly in order that the technical personnel might turn to the specific tasks of development and production for winning over our enemies. Most of the activities involving the supply of equipment for combat, transportation, and defense, consisted of engineering development and production.

It is true that a great many new materials and by-product knowlege evolved from the war activities and much of these will find extensive application in the years of peace and prosperity which we now anticipate.

But it is also true that we must return to a broad program of fundamental research which will provide additional knowledge—theory and new principles on which future practical engineering application will be based.

The contemplated plans for research and development emphasize as never before the great need for highly trained scientists and engineers. The present acute shortage of technically trained men will continue for some years to come, unless heroic steps are taken to seek youngsters with an aptitude for science, and more extensive plans formulated to subsidize their education.

I accept the John Fritz Medal with a sense of humility and recognition of its significance in the progress of our modern technology. May the untiring effort, enthusiasm, and pioneering spirit of the man it commemorates be the inspiration of all those who labor in the expanding fields of science and engineering.

INSTITUTE ACTIVITIES

New Records Established in Program and Attendance at Winter Meeting

By wide margins new records were established at the second AIEE postwar winter meeting, held in New York, N. Y., January 27–31, 1947. A final verified registration of 3,567 exceeds by approximately 40 per cent the previous all-time high record of 2,624, established at the winter meeting in January 1946, and is nearly double the earlier record figure of 1,931 established at the winter meeting in Philadelphia in January 1941. The winter meeting program, too, established an all-time high record in the number of general and technical sessions, technical conferences, business conferences, and working meetings of committees, subcommittees, and working groups of committees.

The extent and variety of subject matter offered in the winter meeting program proved its worth-whileness in the record registration, and in the heavy attendance and active participation noted at the various sessions and conferences. Of the 29 technical sessions and 10 technical conferences, three were devoted to subjects pertaining to land transportation, and two sessions devoted to subjects pertaining to air transportation. Basic science subjects, including discussion of new energy sources, accounted for two sessions, while industrial application and control topics accounted for seven busy sessions. Other sessions included three for power transmission and distribution topics, one for hydroelectric systems, four for electric machinery topics, one for lightning, three pertaining to electronics and electronic equipment and applications, two concerned with computing devices and applied mathematics, four devoted to electric protective equipment and procedures, one each covering servomechanisms, statistical methods, and a symposium pertaining to the limitations of artificial light production. Four sessions were devoted to television and other communications subjects including rural radiotelephony. Two administrative conferences were held, one concerning AIEE technical activities, and another concerning Student Branch activities. Highlights of the sessions and conferences appear on the following pages of this section.

Analysis of Verified Registration at Recent Winter Meetings

District	1943	1944	1945	1946	1947
New York (3)	569	608	704	1,123	1,577
Middle Eastern (2)	417	474	463	645	747
North Eastern (1)	254	301	278	474	627
Great Lakes (5)	97	131	153	200	300
Southern (4)	22	80	40	65	118
Canada (10)	25	29	41	52	78
South West (7)	17	21	32	38	41
Foreign	...	...	...	...	40
Pacific (8)	6	4	3	13	24
North West (9)	6	6	3	7	10
North Central (6)	6	4	1	7	5
Totals	1,419	1,658	1,718	2,624	3,567

COOVER ACCIDENT

During the first two days of the meeting, requests for blood donations for Mrs. Coover, wife of Professor M. S. Coover (F '42) were made at all sessions. Mrs. Coover was injured critically January 26 when she was struck by the body of a suicide hurtling from an upper story of the Empire State Building. The requests met with an immediate generous and sympathetic response, and by Thursday, January 30, Professor Coover announced that Mrs. Coover was out of danger to her life. As of February 12, Mrs. Coover was reported as steadily improving and allowed to spend an hour or so each day up in a wheel chair.

THREE MEDALS PRESENTED

The 1947 winter meeting brought again to the AIEE the distinction of having three of its renowned members receive three of the highest awards of the engineering profession: the Edison Medal, the John Fritz Medal, and the Hoover Medal. That each award could be made with individual distinction to the medalist, the committee arranged for three separate presentation ceremonies, in the form of short general sessions preceding the afternoon schedules of technical sessions and conferences. The attendance at these general sessions proved beyond doubt the merit and advantages of this arrangement.

"For pioneering achievements in radio and for the invention of a grid-controlled vacuum tube with its profound technical and social consequences," the AIEE Edison Medal for 1946 was presented to Doctor Lee de Forest (F '18) of Chicago, Ill., Tuesday afternoon, January 28, 1947, with President J. Elmer Housley (F '43) presiding. The origin of the Edison Medal was outlined by S. M. Dean (M '41) chairman of the Edison Medal committee. General David Sarnoff (M '23) of New York, N. Y., presented an outline of the medalist's career, and President Housley presented the medal.

For his "pioneering genius and notable achievements during a long career devoted to the scientific advancement of the production and utilization of electric energy," the John Fritz Medal for 1946 was awarded to Doctor L. W. Chubb (F '21) of East Pittsburgh, Pa. The career of the medalist was reviewed by M. W. Smith (F '42) of Pittsburgh, Pa. Presentation of the medal, on behalf of the four national Founder Societies which sponsor it, was made by N. E. Funk (F '34 past president) of Philadelphia, Pa. Presiding with President Housley for this general session Wednesday afternoon, January 29, was Malcolm Pirnie, past president of the American Society of Civil Engineers, chairman of the intersociety board of award.

The Hoover Medal for 1946 was presented to Doctor Vannevar Bush (F '24) of Washington, D. C., at a general session Thursday afternoon, January 30, "for outstanding public service," as "engineer, educator, and administrator, who, in critical time of need, was in a most special sense an organizer, guiding spirit, and driving force of the nation's achievements in physical and medical science." E. L.

Analysis of Registration at 1947 Winter Meeting

Classification	Dist. 3	Dist. 1	Dist. 2	Dist. 4	Dist. 5	Dist. 6	Dist. 7	Dist. 8	Dist. 9	Dist. 10	Foreign	Totals
Members	1,101	488	568	84	230	5	34	19	9	61	3	2,602
Men guests	367	108	133	22	48		3	2	1	14	35	733
Women guests	67	24	39	11	21		4	3		3	2	174
Student members	42	7	7	1	1							58
	1,577	627	747	118	300	5	41	24	10	78	40	3,567

Future AIEE Meetings

North Eastern District Meeting
Worcester, Mass., April 23–25, 1947

Summer General Meeting
Montreal, Quebec, Canada, June 9–13, 1947

Middle Eastern District Meeting
Dayton, Ohio, September 23–25, 1947

Pacific General Meeting
San Diego, Calif., August 25–29, 1947

Midwest General Meeting
Chicago, Ill., November 3–7, 1947

Winter General Meeting
Pittsburgh, Pa., January 26–30, 1948

Moreland (F '21) of Boston, Mass., outlined the career of the medalist. The medal was presented by Doctor Scott Turner, past president of the American Institute of Mining and Metallurgical Engineers and chairman of the intersociety Hoover Medal board of award.

The full texts of the addresses delivered at the three medal ceremonies are given elsewhere in this issue of *ELECTRICAL ENGINEERING.*

ENTERTAINMENT

The annual smoker held Tuesday evening at the Commodore Hotel, and a women's luncheon and bridge held Wednesday, January 28 at the Engineering Women's Club constituted the principle features of the organized entertainment program. The usual dinner dance was dispensed with because of the extensive cost involved. A special feature of the entertainment program was the cocktail party given in the Grand Ballroom of the Biltmore Hotel Thursday evening, January 29, by the Aluminum Company of America for President J. Elmer Housley. This affair was heavily attended and was an outstanding social success, many members expressing a desire for continuation of the idea in lieu of the usual and more expensive dinner dance.

INSPECTION TRIPS

An interesting and comprehensive schedule of inspection trips was provided, co-ordinated as far as possible with the various technical sessions both as to timing and as to subject matter. These included:

1. The RCA Laboratories at Princeton, N. J., where various equipment and materials were shown and demonstrated, including an equation solver, an "antennalyzer," an electron microscope, and an infrared telescope.

2. Grumman Aircraft Engineering Corporation at Bethpage, N. Y., where visitors were able to review the production line method as applied to the manufacture of military and commercial aircraft.

3. Bell Telephone Laboratories at Summit, N. J., where some of the most modern research facilities were displayed, and recent development in metallurgical research, rubber products and applications, synthetic crystals, and radar were reviewed.

4. Waterside Generating Station in New York, features of which included high-pressure boilers capable of producing 600,000 pounds of steam per hour at 925 degrees Fahrenheit and 1,400 pounds per square inch pressure; also four topping turbine generators.

5. Columbia Broadcasting System Television Station in New York, where visitors were able to witness both the sending and the receiving of images.

6. Pennsylvania Railroad, and New York Central Railroad facilities where visitors were shown the wide variety of electric equipment required for modern railroad passenger cars.

ELECTRICAL SHOW

An "Electrical Engineering Exposition" featuring a variety of equipment and matériel was held at the 71st Regiment Armory in New York, under the management of International Exposition Company. This exposition was an activity entirely independent from the AIEE winter meeting, but held concurrently with it, and drawing heavy attendance from among those attending the winter meeting. Arrangements were co-ordinated with the winter meeting committee.

COMMITTEE ACTIVITIES

Some 51 committees, 40 technical and 11 administrative, held one or more business sessions during winter meeting week. Also, there was the usual winter meeting of the AIEE board of directors. The highlights of these meetings are reported elsehwere in these pages.

Personnel of the working committees which were responsible for convention activities includes the following:

Winter Convention Committee: C. S. Purnell, *chairman*, W. J. Barrett, O. E. Buckley, P. C. Cromwell, M. D. Hooven, R. A. Jones, A. E. Knowlton, J. H. Pilkington.

Smoker: C. T. Hatcher, *chairman*, W. J. Barrett, C. F. Bolles, A. J. Cooper, H. E. Farrer, J. B. Harris, Jr., S. B. Henderson, William Jordan, E. B. King, J. P. Neubauer, E. G. D. Paterson, D. M. Quick, H. B. Snow, D. W. Taylor, E. F. Thrall, W. R. Van Steenburgh.

Inspection Trips: R. T. Oldfield, *chairman*, D. V. Buchanan, E. F. De Turk, H. E. Farrer, R. W. Gillette, C. N. Hoyler, F. P. Josslon, J. T. Lowe, A. G. Oehler.

Ladies' Entertainment: Mrs. J. F. Fairman, *chairman*, Mrs. T. F. Barton, Mrs. R. F. Brower, Mrs. O. E. Buckley, Mrs. P. C. Cromwell, Mrs. C. W. Franklin, Mrs. R. A. Jones, Mrs. H. S. Osborne, Mrs. J. H. Pilkington, Mrs. J. J. Pilliod, Mrs. C. S. Purnell, Mrs. D. A. Quarles, Mrs. G. S. Rose, Mrs. W. R. Smith, Mrs. G. Sutherland.

Theatre and Broadcast Tickets: H. H. Heins, *chairman*, G. H. Campbell, G. J. Dyktor, W. Hayden, Jr., H. E. Murphy, T. J. Talley, 3d.

Session Summarizes Improvements in Light Traction

The technical session on light traction held January 27 at the winter meeting was headed by W. A. Brecht (M '39) Westinghouse Electric Corporation, East Pittsburgh, Pa. The major part of the meeting was devoted to the proposed New York subway system improvement. Extensive discussion was aroused by a paper on the trolley coach. The hazard of overhead lines to fire fighting stimulated a number of remarks which seemed to indicate that the point was overemphasized.

NEW YORK SUBWAY PLANS

"Rapid Transit Plans for New York," by Major General Charles P. Gross, chairman, Board of Transportation, New York City Transit System, outlined a 3-year program dependent upon a $250,000,000 expenditure for rehabilitation. Part of the new equipment to be installed includes a 60,000-kw high-pressure generating unit. Out of the $76,000,000 appropriation for 1946, contracts have been let for 500 subway cars of a required 1,500. The traffic curve for the first part of 1947 as compared with the same period of 1946 has been seven per cent higher. General Gross showed that the trend of traffic from 1920 to 1930 pointed definitely upward, and that a similar trend is indicated for the immediate future. Need for new construction to the order of $500,000,000 will be essential in relieving the increasing congestion in the subway system. Included in this program of construction is the enlargement of many of the remaining 6-car stations to 10-car stations. Also necessary is a new subway line for the upper part of Manhattan and a new tunnel under the East River. To assure success of this program it is essential that the present 5-cent fare be increased to 10 cents, according to General Gross.

MODERN SUBWAY CARS

"Modern Car Equipment for New York City's Subway System," was presented by B. F. Cordts, New York City Transit System. To replace cars worn by rigorous wartime use, the New York Board of Transportation has placed orders for 400 subway cars to be operated on the Brooklyn Manhattan Transit (BMT) and Independent (IND) Divisions, and for 100 cars to be operated on the Interborough Rapid Transit (IRT) Division of the city transit system. Important features of these new cars, first of which will be delivered this spring, will be better lighting, better riding qualities, smoother acceleration and deceleration, reduction in noise, and better ventilation. Arrangement and dimensions of the new cars remain almost exactly the same, so that the existing subway structures and maintenance facilities will be utilized to the best advantage. The new cars will be equipped with fluorescent lighting of the cold-cathode type, because frequent starting resulting from section breaks and crossovers in the third rail necessitate the use of lamps having instant-starting and long-life characteristics.

An interesting development to determine riding qualities was construction of a lateral motion tester, used to test the newly adopted lateral shock absorbers which will reduce the tendency of trucks to "nose." By turning the device 90 degrees, it can be used as an accelerometer to test the performance of motormen. Improvements in design of the trucks, and extensive use of rubber in their construction will eliminate much of the objectionable noise and lateral motion present in existing cars. The use of dynamic braking will reduce the number of shoe applications to the wheels, and also the shoe pressure. Four antifriction bearing-equipped motors per car, one per axle, were selected, so that accelerating and braking loads would be distributed evenly.

Extreme congestion during rush hours presents a major problem in control of heat. Horizontal fans will provide a much better distribution of air than the five fans blowing vertically in the old cars. Among the other new features will be plastic seat covering, wider door openings to facilitate the interchange of passengers, completely sealed gear cases to eliminate grease drip to tracks, and a car interior designed for easy cleaning.

"Special 10-Car Train for the New York City Transit System," by J. J. Sinclair, New York City Transit System outlined plans the New York Board of Transportation has designed for an experimental 10-car train, embodying many special features not heretofore used in one application in transit vehicles. Increasing congestion of subway trains and structures has attracted

many comments on improvements from the general public. Some of these suggestions have been followed up very thoroughly, but few are incorporated in the new design. Mechanical features of the 10-car train include forced ventilation, a station announcing system, and improved truck construction.

TROLLEY COACH ECONOMICS

"Can the Trolley Coach Compete Economically With the Gas and Diesel Bus When No Overhead Facilities Exist?" was presented by J. H. Gauss, General Electric Company, Erie, Pa. Economics play an important part in the picture of modern transportation. In selecting the proper transit vehicles, many widely different factors must be considered, ranging from public preference to fundamental economics. The trolley coach's economic field of service is the trunk line that does not justify PCC car operation but does justify a large-size vehicle (37–44 passengers). An important consideration in determining the economic suitability of the trolley coach, as compared with the gas or Deisel bus, is that the size and service be similar. The trolley coach has several advantages, among which is that it is not dependent upon heated storage facilities to insure cold-weather starting.

According to figures presented in the paper, economic operation of the trolley coach is less expensive than that of the gas or Diesel bus in similar service. One of the major factors in selection by the public of trolley coaches in preference to gas or Diesel busses is the absence of noxious fumes. In various cities, public voting to determine which type of transportation was to be established gave the trolley coach a decided advantage. The public has objected to the unsightliness of overhead facilities, but the absence of noise and fumes has overbalanced this factor. Another item in the trolley coach's favor is the unlimited power availability for acceleration. The electric motor in the trolley coach operates at between 150 and 200 per cent load for a short period of time during acceleration, making possible faster and smoother pickup and enabling operation at a faster scheduled speed. A 44-passenger mechanical bus with seated load is sluggish getting under way, especially when operating on a slight upgrade, and does not have the reserve power to hold its place with other traffic.

Capacitors Important in Automatic Stations

George S. Whitlow, chairman, opened the session on automatic stations, held at the winter meeting, January 27, by pointing out that the cost reduction resulting from mass production of capacitors has made their use even more advisable for power factor correction than previously. Capacitors may be used in substations banks, housed banks on pole lines, or as individual units. The outstanding problem is the excessive kilovars which appear at off-peak loads. The outstanding questions to be considered by the session were how much saturation of capacitors is permissible, and how much automatic control is available.

ECONOMIES OF CAPACITOR USE

J. W. Butler (M '38) General Electric Company, Schenectady, N. Y., in his paper, "The Economics of Using Capacitors in Amounts to Require Automatic Switching," discussed the economic operating power factor when either current carrying capacity or voltage drop are limiting factors. He concluded that it is now economic to use more capacitors than can be left on the system at all times. He suggests that approximately one third of the whole load requirements of kilovars be supplied by the generators, that one third be supplied by capacitors which may be switched on and off the line, and the final one third be supplied by capacitors which will remain on the line permanently. The final two thirds of the kilovar capacity should be supplied as near to the load area as possible. In the discussion that ensued, it was noted that the capacitors should be supplied by the power company, because it is in the position to supply them at lowest cost, and that the utility should have control of the switching operation. The only exception to this is that the customer needs the generation of kilovars within his own plant. The charge for reactive power should be small, if not zero, and loads at maximum power factor should be encouraged. Practical examples of the use of capacitors were given, and also examples of the use of synchronous condensers for this purpose. For maximum economy the capacitors should be placed as near to the load as possible which would mean placing the permanent capacitors in small quantities near the load and placing the larger banks of capacitors to be switched at the distribution bus. Presentation of the paper and discussion brought out that capacitive reactive power was considered as a positive entity in accordance with the proposed change in the sign of reactive power (*EE Nov '46, pp 512–16*).

CAPACITOR SWITCHING

Automatic switching schemes for capacitors were considered in the paper by W. H. Cuttino (A '44), Westinghouse Electric Corporation, East Pittsburgh, Pa. Capacitive kilovolt amperes may be adjusted automatically by varying the voltage on the capacitor. The automatic control of a tap-changing transformer which in turn controls the voltage across a given capacitor bank is a method of accomplishing this, but it is not economical and is seldom used. The number of capacitors may be varied by automatically switching in equal or unequal steps in response to voltage, current, reactive power, or power factor of the circuit. Each bank of capacitors is switched by its own circuit breaker. If unequal banks of capacitors are used to obtain a large number of combinations which supply small steps of reactive power values, it may be found that many instantaneous changes are less desirable than fewer and larger changes of reactive power. Capacitors also may be connected directly to a piece of equipment which draws highly lagging power, or may be connected nearby and switched by the same switching means which control the equipment. Similar schemes for providing both leading and lagging power may be had by connecting both capacitors and reactors to the automatic control units. Several specific examples of installations of automatic control devices were given by the discussers.

"The Automatic Control of Air Switches for Lines Sectionalizing and Load Transfer" by F. W. Rich (A '41) and M. S. Kirwen (A '42), Commonwealth and Southern Corporation, Jackson, Mich., a paper which had been presented at the summer meeting, was presented by title only. The discusser described similar installations and their methods of operation.

Initial Session on Metallic Rectifiers Held

At the technical session of the subcommittee on metallic rectifiers, on January 27 at the winter meeting, E. A. Harty (M '36) of the General Electric Company, Lynn, Mass., who is also secretary of the subcommittee on metallic rectifiers, presided. This subcommittee was established $2^1/_2$ years ago, and since has met 20 times, accomplishing a great amount of work in furthering the study of metallic rectifiers. This was the first technical session on metallic rectifiers, and a turnout of 168 men showed promise for many future sessions.

SUBCOMMITTEE REPORTS

The two conference papers presented at the meeting, "Bibliography on Metallic Rectifiers and Their Principle Applications," and "Proposed Standards for Metallic Rectifiers," were received by the listeners as excellent examples of the work and efforts of the subcommittee members. The bibliography represents three years of work by the committee members. It consists of 514 classified references and is intended to serve not only research workers and students, but also design and application engineers, who daily are discovering the increasing utility of the metallic rectifier. "Proposed Standards for Metallic Rectifiers" is another accomplishment of this newly formed subcommittee. These standards are only tentative and have not been approved by the Standards committee. However, they have been printed at this time with the hope of promoting further comment and discussion. Comments on the tentative standards are to be mailed to E. A. Harty, Marblehead, Mass. With these suggestions and the proposed standards of 1947, it is hoped that within five years a final approved standard for metallic rectifiers will be published.

ELECTRONIC SEMICONDUCTORS

The first paper presented was "The Physics of Electronic Semiconductors," by G. L. Pearson of Bell Telephone Laboratories, Inc., New York, N. Y. The peculiar qualities and resistivities of semiconductors

were compared with those of typical metals. In his paper, Mr. Pearson outlined the theories relating to semiconductors, correlating them with experimental data. The relatively new band theory of solids, the effect of impurities upon the conductance of semiconductors, the photoelectric effect upon semiconductors, and the importance of the "Hall effect" in calculating density and mobility were dealt with in detail.

COPPER-OXIDE RECTIFIERS

I. R. Smith (A '43) of Westinghouse Electric Corporation, East Pittsburgh, Pa., traced the progress made in the development of copper-oxide rectifiers, which was the subject of his paper, "Higher-Voltage Copper-Oxide Rectifiers." The life of a copper-oxide rectifier is indefinite, and there is still no indication of its limitations when properly designed and used. Growth of this type rectifier progressed from a simple stack to its present form, having increased output as a result of fan cooling. By reducing the losses which must be dissipated by the rectifier, its design will be improved even further. The vacuum-preanneal process of manufacture was used on the 3,000-volt rectifiers at *KDKA* broadcasting station in Allison Park, Pa., which are mounted in a duct in the floor, with air blown up through the stack and exhausted at the top of the cubicle. The latest manufacturing method developed is the type *Q* process, which has resulted in rectifiers for even higher-voltage applications, such as in the radiobroadcasting field, showing such advantages as simplicity of control, instant starting, elimination of any warm up, and most important, freedom from maintenance and unpredictable failures. Copper-oxide rectifiers are expanding in the field of usefulness with increase in output rating. During the discussion, Mr. Smith stated that the 3,000-volt rectifiers at *KDKA* had been in operation since November 1939, 18 to 20 hours per day, with no maintenance problem.

SELENIUM RECTIFIER

"Electrical Characteristics of the Junction in a Simplified Selenium Rectifier Cell," by Stephen J. Angello (A '42) University of Pennsylvania, Philadelphia, Pa., extends the theory of W. Schottky, which predicts the contact resistance of a selenium rectifier cell at zero voltage. In extending this theory the author assumes a portion of the bromine ions in the selenium to be free. Experiments prove that there is a discrepancy between Schottky's theory and actual measurements at higher voltages.

AUTOMATIC RECTIFIERS

J. J. Buckley (A '41) of General Electric Company, Lynn, Mass., presented "Automatically Controlled Copper-Oxide Rectifiers for Electroplating and Anodizing Applications," in which some of the underlying principles governing the rating of the copper-oxide cell and types of copper oxide stacks used in electroplating and anodizing applications were the assembly of the 12-kw rectifier unit which is generally a component of automatically controlled installations was described in detail. Desirability of having a varying alternating voltage applied to the unit was mentioned, and the induction type control used for this purpose was described. Circuits were presented for maintaining constant voltage, constant current, and so forth, and characteristics, such as over-all efficiency and power factor, were included.

RECTIFIERS IN SWEDEN

One of the interesting features of the session was a brief talk by D. Van Reis, of Sweden, who is traveling throughout the United States on an American-Scandinavian fellowship. Mr. Van Reis reported briefly on the manufacture of selenium rectifiers in Sweden, which prior to World War II were purchased solely from Germany. The impact of the war forced Swedish manufacturers to produce selenium rectifiers, the process being taken up surprisingly fast because of early research in this particular field. The recent trend has been to assemble the rectifiers without fans. Rectifiers using selenium cells have been used for as high as several hundred kilovolts in precipitation plants with very good results. Demand for rectifiers in Sweden is very high, he said, and will become even greater, when Swedish engineers become more familiar with this comparatively young electric device.

Student Branch Counselors Confer

A conference of AIEE Student Branch counselors was held January 27 during the winter meeting. J. F. Calvert (F '45) chairman of the AIEE committee on Student Branches and chairman of the electrical engineering department, Northwestern Technological Institute, Evanston, Ill., presided.

One of the principal subjects discussed was the matter of rules for the admission of new Student Branches. Several schools in the United States and Mexico have made application or inquiries regarding the formation of Student Branches, and the discussion was broadened further to include the matter of technical institutes and other schools that now are being established rapidly. In particular, the relation of Engineers Council for Professional Development accrediting of schools to the admission of Student Branches was discussed. A motion was made and approved that accrediting may be considered adequate and sufficient evidence of the scholastic standing of a school for acceptance of a Branch, but that it is not a requirement.

The view was expressed by D. D. Ewing (F '21) head of the School of Electrical Engineering, Purdue University, Lafayette, Ind., that AIEE has a role to perform in both a professional and an educational capacity, and that, in order to carry out its educational functions, it may not be desirable to set the standards for admission too high. Other discussers mentioned the formation by the American Society of Mechanical Engineers of clubs in nonaccredited schools. Members of these clubs may subscribe to *Mechanical Engineering*, but the group does not have the full status of a student branch. It was considered that nonaccredited schools might be asked to form electrical clubs, pending a year or two of development.

BRANCH AND SECTION CO-OPERATION

Activities of the New York Section with relation to Branches in the Section territory were described by J. H. Pilkington (M '34) chairman of the Section, and assistant to rate engineer, Consolidated Edison Company of New York, Inc., New York. Branches in the area have some 900 members, and a substantial increase is expected by the end of the school year. Talks by Section officers are arranged at Student Branch meetings, if it is so desired. The Section also has assisted schools in obtaining temporary instructors, in some instances drawn from retired members of companies in the area. The monthly bulletin of the Section is sent to all members, including students, and the latter also are furnished with copies of the ECPD reading list. Student Members served as volunteers in the performance of various functions at the winter meeting.

Other Sections reporting close co-ordination between Section and Branch were Philadelphia, Chicago, and San Francisco.

PROFESSIONAL GUIDANCE

Emphasis was placed on the need for impressing upon the students that engineering should be regarded as a profession and not as a craft. Two paths now are being followed by graduate engineers in an attempt to gain recognition—one large group joins the ranks of registered professional engineers and usually also joins one of the technical professional societies, while another group, usually younger, tends to turn toward union membership. In New York the appeal of the latter path has been mostly to the engineers in large companies. While it is admitted that unions are here to stay and have a definite place in present-day organization, it is questionable if professional status can be obtained by following this path.

WELCOME TO ELECTRICAL ENGINEERS

An address of welcome suitable for use as an introduction of students to the Branch has been prepared by Tomlinson Fort (M '35) which is available for use as an outline or as a preface for a Branch talk. However, it is not suitable for use before joint branches. Use of publications of the ECPD such as "The Second Mile" (*EE, May '42, pp 242–7*), was suggested. This year, particularly, students are looking ahead and thinking about where they can place themselves, and to some extent find themselves confused. Difficulty has been experienced in getting students to read material that would orient them; they want to be told. It is to meet this need that the New York Section has conducted a service which has counseled more than the 1,000 veterans at weekly meetings, as has

been described previously (*EE, Aug–Sept '46, p 410*).

Incidentally, it was said that this counseling service has been so successful as to warrant its continuance in the form of meetings to advise individuals on problems in orientation in the profession. Appointments for consultation with qualified engineers are made if questions cannot be answered at the meetings.

PRIZES FOR STUDENT PAPERS

It was recalled that a report in 1943 had recommended the establishment of prizes for student papers and that it is still pending. It had been proposed that students compete in Branch competitions, the winner to enter a District competition, with half the Districts competing each year, during the AIEE summer meeting. The present prize for a Student Branch paper would not be affected. Discussion of the subject led into the problems of differentiating between students in 4- and 5-year curricula and the question of including graduate students. Provision for the last group, however, already has been made. A motion was made that action be taken on prizes for undergraduates and that the committee on Student Branches be urged to report.

JOINT STUDENT BRANCHES

Formation of joint branches of AIEE and Institute of Radio Engineers was authorized last year by the AIEE board of directors (*EE, Apr '46, p 167*) where local conditions may seem to make such a joint group desirable. It was reported at the conference that the joint Student Branch at Northwestern University was operating successfully, representatives of the school stating that the plan is desirable particularly in instances in which a school desires to sponsor only one branch. This raises the perennial question as to whether a Student Branch should be essentially an autonomous group operating on the basis of the interest and initiative of the student group, or be "sponsored" by the school, sometimes to the extent of becoming in effect just another classroom or seminar-type activity. At Northwestern University, the IRE board of directors has not yet taken official action, some students belong to both the AIEE and IRE national organizations. The general plan of operation is that the branch president be a member of either of the societies, and that there be two secretaries, one for each of the basic national societies.

There was no showing of the film mentioned in the winter meeting program pamphlet.

Industrial Electronic Devices Described

C. H. Willis (F '42) Princeton University, Princeton, N. J., introduced the speakers at the technical session on electronics at the winter meeting on January 27. "The Shunt Tube Control of Thyratron Rectifiers," by J. A. Potter, Bell Telephone Laboratories, Inc., New York, N. Y., described a scheme for obtaining a highly constant rectified voltage with very low a-c ripple content. The shunt tube type of regulated rectifier features rapid regulating response to abrupt changes in line voltage, load current, source voltage, and source frequency, and a high degree of ripple suppression. A vacuum tube is employed with the plate circuit connected as a shunt on the regulated output of the thyratron rectifier. This tube eliminates variations due to transients beginning at points in the half cycle after the thyratron has fired. The tube plate current is an uneconomic load on the unregulated power supply, but is small enough not to damage the over-all efficiency of the system. The regulating circuit of the grid of this tube is sensitive to output voltage changes and automatically adjusts plate current as required. The shunt tube effectively regulates intermediate frequency changes; the thyratron itself regulates d-c and low frequency changes; and a final filter capacitor removes high frequency variations.

CONTROL SYSTEM

O. W. Livingston (M '43) General Electric Company, Schenectady, N. Y., in his paper, "Electronic Constant Current Motor Systems," developed a control system. By an appropriate vacuum-tube control circuit a d-c motor may be made to have constant current, constant speed, or constant torque characteristics. Controls also are included to prevent overvoltage and overcurrent.

A conference paper, "Sealed Ignitrons for Power Rectifiers," by W. E. Pakala (M '45) and C. R. Marcum of Westinghouse Electric Corporation, East Pittsburgh, Pa., was presented by Mr. Pakala. It reviewed the development of ignitrons and methods of maintaining vacuum in them. The design and construction of the 400-ampere ignitron, the largest capacity ignitron now in production, was given in detail. L. W. Morton (M '45) General Electric Company, Schenectady, N. Y., in his discussion reviewed the sizes of ignitrons now in use. H. C. Steiner, General Electric Company, Schenectady, N. Y., compared the American manufactured ignitrons with those constructed in Europe.

Mr. Pakala also presented a paper written by himself and C. J. Cuculla, of Westinghouse Electric Corporation, East Pittsburgh, Pa., entitled "Arc-Back Testing of Graphite." The arc-back characteristics of various grades of anode graphite for ignitrons were investigated. It was noted that in every case the arc-back rate test start was greater than the steady-state value which was reached after several hours. Anodes coated with semiconducting particles which cannot be removed completely by preheating apparently are removed by arc-backs. It was found that nonconducting materials increased the arc-back rate, but an unpredictable result was obtained when steel particles embedded in the anode did not increase the arc-back rate. The arc-back rate distribution curve was almost in phase with the positive ion current waves. Arc-back rate increased with voltage, and operation at high voltages improved the performance when the anode was returned to lower voltages. Degassing reduces the arc-back rate. Discussion pointed out that certain materials on the cathode reduce the load capacity of an ignitron.

The session was closed by an announcement from Doctor R. W. Clark (A '36) of the Magnavox Company, Fort Wayne, Ind., describing a questionnaire prepared by the AIEE subcommittee on electronic instrumentation. A survey is being conducted to determine the special types of vacuum tubes for which there is a demand. This questionnaire has been sent to 500 manufacturers. Doctor Clark asked those who had received questionnaires to be sure that they were returned promptly, and announced that any company which had not received a copy could obtain one from C. C. Wilson (M '43) at AIEE headquarters, 33 West 39th Street, New York 18, N. Y.

New Developments for Electric Railways Discussed

The technical session on electric railways, attended by approximately 100 engineers, was presided over by W. A. Brecht (M '39) of the Westinghouse Electric Corporation, East Pittsburgh, Pa., who is chairman of the committee on land transportation.

HIGH-SPEED COLLECTORS

The paper, "Developments in Current Collectors for High-Speed Service," by B. F. Langer of Westinghouse Electric Corporation, East Pittsburgh, Pa., revealed that at high speeds difficulty has been encountered with the behavior of pantograph shoes and secondary springs. Some of the phenomena observed were: fluttering of the shoe against the wire resulting in excessive arcing; difficulty in obtaining equal pressure on both shoes of double-shoe pantographs; secondary spring systems which use pins and links have a tendency to bind and nullify secondary springing. Mr. Langer's paper describes studies made by Westinghouse which have disclosed some of the causes of erratic operation and finally have resulted in a shoe and shoe mounting which gives smooth operation at the highest operating speeds.

PCC CAR DEVELOPMENTS

"Some Recent Developments in the PCC Car" was presented by S. B. Cooper of the Westinghouse Electric Corporation, East Pittsburgh, Pa. Growth of the co-operative research program to improve the transit cars of the large cities was traced from its start in 1929. The first Presidents' Conference Committee Car was ordered early in 1935, and the latest version of this car, the 1945 model, shows that further innovations have been carried out in this program. Improvements outlined in Mr. Cooper's paper include body features, such as wider aisle width and standee windows; better operating vision for the driver;

ventilation without unpleasant drafts; improved braking system; and improvements in the motor permitting longer brush life. However, car weights have tended to increase, and future developments will aim towards weight reduction by the use of lighter metals. The success of the PCC car is borne out by the fact that it is used widely throughout the United States and foreign interest has been shown. The PCC car has justified fully the time, effort, and money spent on this research program.

S. J. Vouch, of the General Electric Company, Erie, Pa., presented a paper, "Recent Developments in Track Brakes and Drum Brakes for PCC Cars," which explained details of construction and characteristics of the magnetic track brake and drum brake, which recently have undergone extensive design changes. The variety of braking permits the driver to use the full motive capacity with safety. Automatic application of the drum brakes on failure of low-voltage power has made it possible to eliminate the hand brake for parking.

SILICONES TESTED

The paper, "Investigation of Silicone Insulation on High-Temperature Railway Motor," by George Grant III (A '44) and T. A. Kauppi (A '44), both of Dow-Corning Corporation, Midland, Mich., and Graham L. Moses (M '44) of the Westinghouse Electric Corporation, East Pittsburgh, Pa., reported that a comprehensive test program was begun in the fall of 1943 to determine the behavior of silicone insulating materials in electric motors. The main objective was to determine the relation between operating temperature and service life for silicone-insulated motors and to compare the behavior with that of class *A* and class *B* insulated motors when subjected to the same type of test cycle. This testing cycle consisted of periods of high-temperature operation of the motor alternated with periods of severe humidification during which the condition of the insulation could be determined. The railway motor chosen for test was the one used at that time on standard PCC street cars. The only changes made were to utilize silicone-treated and bonded materials wherever possible. After 1,675 hours of operation at 285 degrees centigrade, the unit was examined. A temperature test disclosed that heat dissipating ability of the winding had remained essentially unchanged by the severe aging test. Upon completion of all tests the motor was disassembled. In most places the varnish film was intact and in very good condition; insulation was flexible and still well bonded; and conductors were well bonded and silicone filling cement was solid.

These tests indicate that the moisture resistance is maintained at a high level, even during severe accelerated thermal aging, and that thermal endurance of silicone insulation may be utilized to increase thermal life expectancy of insulation to many times that of class *B* insulation under the same temperature conditions. The authors pointed out that it would be of considerable value, if electric railway machines design engineers considered the advantages to be obtained by increased operating temperatures. This paper provoked much discussion, most of which substantiated the authors' viewpoints on silicone insulation for electric motors.

Co-operation of AIEE and American Mathematical Society

Doctor Michel G. Malti (M '45) Cornell University, Ithaca, N. Y., presided at this well-attended winter meeting session held in conjunction with the American Mathematical Society on January 27. After several introductory remarks by Doctor Malti, who is chairman of the AIEE mathematics subcommittee, conference papers were presented, ranging from fluid flow patterns to automatic computers. Following the presentation of the papers, discussions on the philosophy of the mathematician and physicist, as compared with those of the engineer, were presented.

FLOW PATTERNS

Doctor Garrett Birkhoff, of Harvard University, Cambridge, Mass., presented "Fluid Flow Patterns," in which he gave an analogy between a sphere moving rapidly in a fluid and the field of an electric dipole, thereby illustrating the similarity between practical hydrodynamic flow, as compared to electric fields. The problem of a torpedo entering the water projected research along such lines. Illustration of similarity between hydraulic flow and the lines of an electric field was brought about by introduction of hexane bubbles rising vertically in the water in which the torpedo experiment was carried out. Shadow pictures of the experiments showing the bubble paths were made to illustrate these effects. Doctor Birkhoff pointed out that the hydraulic experiment, when applied to an electrical problem, gives the wrong solution, however.

PROBABILITY IN ELECTRICAL PROBLEMS

"Probability as Applied to Some Electrical Engineering Problems," by Doctor Mark Kac, Cornell University, Ithaca, N. Y., illustrated the effect of random noise in electronic devices. A radar receiver would be dependent upon the operator for interpretation of signals as affected by a certain random noise level which introduces extraneous patterns on the oscilloscope screen. If the noise level is comparable to the signal strength, the interpretation of the visible indication lends itself very well to statistical methods involving the theory of probability. This may be illustrated by an operator's mistaking noise for actual radar targets, and conversely, mistaking actual targets for noise.

DIFFERENTIAL ANALYZER APPLICATIONS

"Applications of the Differential Analyzer," by C. Concordia (M '37) General Electric Company, Schenectady, N. Y., explained that the analyzer is adapted to the solution of total differential equations. From an engineering viewpoint, classification of problems solved by the analyzer include: mechanical transients, variable compressible-fluid flow, rotating electric machinery, nonlinear circuits of mechanical and electrical nature, automatic control, and trajectory problems, which are really transient mechanical problems, but of such tremendous volume that they are considered as a separate classification. An important example of solution of variable compressible-fluid flow problems is in the application to aircraft shock absorbers. Application of the differential analyzer to the problem of field current application to synchronous motors was illustrated by Doctor Concordia. It is essential that trained mathematicians and engineers prepare the information used by the analyzer to solve problems.

AUTOMATIC ELECTRONIC COMPUTER

Doctor John von Neumann, of the Institute for Advanced Studies, Princeton, N. J., mentioned possible development of a digital computer having a multiplication speed for two 10-digit numbers approaching a tenth of a millisecond, and outlined in his paper, "Automatic Electronic Computers," two classifications of computing devices—the analogy device and the digital computer. As examples of the analogy device, Doctor von Neumann mentioned the wind tunnel and differential analyzer.

Of increasing importance in the development of computers is the random noise factor, produced in the electronic devices, which introduces errors. Digital computers are confined to approximation because of the limited number of digits which can be accommodated.

DISCUSSION

C. F. Ball (F '38) Johns Hopkins University, Baltimore, Md., was emphatic in his contention that the physicist is playing a larger and larger role in the practical technological development of the world. Doctor Ball mentioned that the physicist has enjoyed a greater popularity, since the production of the atomic bomb, than he ever had previously.

Joseph Slepian (F'27) Westinghouse Electric Corporation, East Pittsburgh, Pa., asserted that the mathematician is concerned with the theoretical possibilities that various systems *may* produce, the physicist is concerned with *how* phenomena occur, and the engineer is interested in *doing* something with what has been made available by the mathematician and physicist, thereby showing the relation among the three.

Technical Activities Studies Reviewed

A conference session to review the work of the technical activities subcommittee of the AIEE committee on planning and co-ordination was held January 27 during the winter meeting with M. D. Hooven (F '44) chairman of the subcommittee and of the technical program committee, presiding.

The proposed changes in AIEE technical activities and committee organization were

outlined as previously published. (*EE, Jan '47, pp 81–82*). At the conference the steps leading to the proposed reorganization were reviewed, and the chairmen of the four co-ordinating committees summarized the activities assigned to them under the plan. Briefly, the technical program committee's plan is for the Institute's technical committees to be under one of four classifications—general applications, power, communications and science, and industry. Samuel G. Hibben (M '45) is chairman of the co-ordinating committee of the general applications group; M. J. Steinberg (M '32) of the power group; W. R. G. Baker (M '41) of the communications and science group; and Herbert Speight (M '21) of the industry group.

Advantages of the proposed organization are held to be the relatively easy establishment and disbanding of joint technical committees and subcommittees to accommodate specific assignments and projects; also the ease of exchanging information between chairmen of committees. Because of the burden of work involved, it is considered undesirable that the chairman of a co-ordinating group also be a chairman of a technical committee.

The need for a flexible organization was stressed, together with the desirability of being able to include nonmembers of AIEE on committees established for a specific objective. One major objective was cited as the making of the technical meetings more human and interesting.

Mr. Speight, discussing the activities of the industry group, indicated that the group is looking for closer co-operation with other specialized industries, such as mining, when electric power is involved. He stated that the proposals have met no criticism so far; in fact, that the general expression of opinion is that some such reorganization should have been commenced years ago.

Mr. Steinberg cited the present organization of the protective devices committee with its five subcommittees as a sample of how the ultimate plan may be expected to develop. He emphasized the need for bringing in more and younger members to participate in Institute activities, and of providing a continuing influx of "new blood."

PRESIDENT'S MESSAGE

AIEE President J. Elmer Housley addressed the conference briefly, and referred to the technical activities as the Institute's common denominator. He stated that he has found in his visits to Sections and Subsections that the industrial field is expanding rapidly and that increasingly more electric devices are being used. The engineers in industrial work necessarily are becoming more highly developed. He stated that the real test of technical activities is membership acceptance, and by broadening the field no technical activity will be neglected.

SECTION TECHNICAL ACTIVITIES

It was stated that in many small cities only AIEE has held technical meetings and that these have been attended by engineers of other professional and technical groups. The proposed new organization increases opportunities for co-operation between the national technical committees and the technical groups in the Sections. Experience in 1944–45 with the instruments and measurements committee, which encouraged Sections to form instruments and measurements groups, was held to be an example of the sort of co-operation that might be effected.

Stronger representation of Sections on technical committees was advocated, when there is much activity in a Section in a particular field of a committee. A suggested method of obtaining this representation was that the Section select the field in which it desired to be most active, recommend candidates for committee membership, and furnish full information to the Institute's president, who is the nominal appointer of committees.

IMPROVED MEMBER SERVICE

F. L. Lawton (M '36) vice-president of the AIEE Canada District (10), stated that the bulk of the AIEE membership was not being reached to best advantage. He recommended four points for improvement:

1. Technical committees should report once a year covering the progress of the art in their subject fields.
2. Sections should propose properly qualified members to the Institute for a "technical committee pool."
3. Digests of the work of the technical committees should be published in *ELECTRICAL ENGINEERING*.
4. Minutes of technical committee meetings should be sent to those Sections having an interest therein.

The desirability of replacing one third of the membership of technical committees annually was discussed from the opposing standpoints of the desirability of bringing new personnel into activities and of losing the benefit of long terms of experience in committee activities.

Considerable discussion was directed to the matter of placement of committees such as Standards and education in the proposed organization. An opinion was expressed that the latter could be considered as either a general or a technical committee, provided necessary contacts were maintained.

BENEFITS IN PROGRAMS

The present winter meeting program was held to be an example of the benefits of the planning possible in the new organization. Papers of common interest, instead of being scattered over several days, were grouped, so that interested individuals could attend the presentations without undue difficulties and conflicts.

There was some discussion of whether or not the technical program committee should concern itself principally with the planning and arrangements for general meetings programs as contemplated in the present AIEE bylaws, or interpret "program" more broadly to include all institute technical activities, including those of local Sections. The fact that perhaps only 4,000 members can attend the general and District meetings was cited by Chairman G. W. Bower of the Sections committee as indicating the gap that must be filled by Section activities.

Protective Devices Session Attracts Large Attendance

A very well-attended session on protective devices was held Tuesday, January 28, under the chairmanship of H. J. Lingal (M '41) Westinghouse Electric Corporation, East Pittsburgh, Pa. Of the four papers presented at the session, two were concerned with matters pertaining to charging currents and its interruption, while two described the operation of rural electrification systems. All of the papers attracted considerable discussion.

HIGH-VOLTAGE SWITCHING

"The Interruption of Charging Current at High Voltage," one of the sources of overvoltages on power systems, was the subject of a paper by W. M. Leeds (M '38) and R. C. Van Sickle (M '37) both of the Westinghouse Electric Corporation, East Pittsburgh, Pa. The paper evaluated the effect of both the circuit constants and the characteristics of the various types of interrupters used in the modern high-voltage oil circuit breakers on the magnitude of switching surges. Though the switching of high-voltage transmission lines and underground cables occasionally produces overvoltage surges on electric power systems, the authors stated that, in contrast to the extreme overvoltages predicted by theoretical studies, a review of several hundred field tests over the past ten years, including many tests with voltage records by cathode ray oscillograph, discloses practically no cases of line or bus surge voltages on solidly grounded systems reaching transient peaks as high as $2^1/_2$ times normal line-to-ground crest voltage. As the severity of switching duty has increased, improved circuit breakers have been developed which give better performance not only on fault interruption but also on charging current interruption. While it is possible to construct circuit breakers that are capable of interrupting charging currents even at the highest voltages without any restriking, such extremes are not usually necessary. For the rare instances that may occur, protective gaps or lightning arresters can be relied on to protect important pieces of equipment.

In his discussion of the paper, T. M. Blakeslee (M '38) of the Los Angeles Department of Water and Power, noted what he termed an attitude of hopeful optimism on the part of the authors, whereas he believes that the engineer should take the pessimistic view. He stated that, though a phenomenon may occur but rarely, the equipment should be prepared in anticipation of the time when these phenomena may occur. This viewpoint was concurred in by E. W. Boehne (F '43) of the General Electric Company, Philadelphia, Pa. In his closure, Mr. Leeds, coauthor of the paper, agreed with the discussers that switching surges will be important and that it will be economically feasible to incorporate apparatus in the circuit breakers to keep restrikes down, especially in future equipment employing 300,000 or 400,000 volts. However, he stated that the purpose of the Leeds–Van Sickle paper was to reassure owners of 60,000-volt equipment,

whose main interest is in whether their present equipment is safe, that there is no problem of immediate danger.

Long high-voltage lines, high-voltage underground cables, and the growing popularity of capacitor banks have focused attention of circuit breaker engineers on problems of charging current interruption. The second paper on this subject, "Resistors for 138-Kv Cable Switching," by E. K. Sadler (M '29) Kelman Electric and Manufacturing Company, Los Angeles, Calif., and T. M. Blakeslee, Department of Water and Power, City of Los Angeles, Calif., presented the situation with respect to 138-kv cable installations in Los Angeles and indicated how overvoltages incident to switching these circuits are limited by resistors installed across main contacts of the circuit breaker. Test results support the idea that arc restriking in the self-extinction principle oil circuit breaker is a "random thing." The paper defined theoretical limits of overvoltages that may be expected and thereby provided the necessary data for the design of a resistor installation for any particular application. There thus is added to a growing list another application of the resistor as a solution to a charging current interruption problem.

IMPROVED RECLOSER

"An Improved Automatic Circuit Recloser" was presented by J. M. Wallace (A '41) Westinghouse Electric Corporation, East Pittsburgh, Pa. Automatic circuit reclosers have been in use for a number of years, making possible a degree of service continuity not previously attained. As loads grow, and as the number of electrically driven machines and appliances used by the consumer increase, the need for better continuity grows apace. The paper presented improvements in one type of automatic circuit recloser. G. Fred Lincks (M '44) General Electric Company, Pittsfield, Mass., in considering Mr. Wallace's recommendations on the application of reclosers stated that the best distribution overcurrent protection practice appears to be that of applying all fuses and reclosers on the circuit in accordance with the modern concept and making certain that characteristics of the reclosers permit full advantages to be obtained with such an application. The paper also was discussed by A. Van Ryan (A '44) Kyle Corporation, South Milwaukee, Wis., who stated that fuses do not have the ability to interrupt and automatically restore service indefinitely and therefore cannot be depended upon to co-ordinate with automatic circuit reclosers having single time-current characteristics. Low revenue, he said, does not warrant the cost of automatic reclosers on small branches extending from main lines as well as from the main branch lines, and thus inexpensive fuse cutouts are used at these points on the system. To permit the use of fuses, and yet provide complete protection, according to Mr. Van Ryan, the automatic circuit recloser having dual time-current control characteristics was developed. In such a system the transient faults are cleared and service is restored by the automatic reclosers or the fuse, depending upon which one of these protects the faulted section.

RURAL PROTECTION

"Sectionalizing and Internal Transformer Fusing on Rural Power Circuits" by Bruce O. Watkins (A '43) Rural Electrification Administration, United States Department of Agriculture, Washington, D. C., discussed the co-ordination of internal transformer fuse links with lines sectionalizing devices on 7.2/12.5-kv multigrounded neutral rural lines, and methods for improving this co-ordination and the electric service to farm areas. An internally mounted primary fuse link is an integral part on a large number of the transformers supplied to rural electric systems. In the interest of more adequate sectionalizing and less interrupted power, aimed toward the improvement of electrical service to the farm consumer, the author included suggestions that internal links of various transformer manufacturers should be standardized, that the characteristics of the internal links, as well as the characteristics of sectionalizing reclosers should be designed for better co-ordination, that the rating of the link in the conventional internally fused type transformers should be no greater than that in the entirely self-protecting type of the same rating, and that system studies should give consideration to proper co-ordination of reclosers and transformer protective equipment. In discussion of this paper J. M. Wallace pointed out the necessity of proper use of time-current curves in all co-ordinated studies. Mr. Lincks added that the solution of the problem of co-ordination with internal fuses must provide not only for the co-ordination of reclosers with internal fuses, but also of internal fuse to branch fuse, branch fuse to line sectionalizing fuse, and line sectionalizing fuse to recloser.

Cathode-Ray Tube Important in Instruments

Opening the session on electronic instruments, held January 28, W. R. Clark (A '36) The Magnavox Company, Fort Wayne, Ind., chairman, noted that the cathode-ray tube, indispensable part to three of the four papers presented, provides fascinating study which only recently has been transferred from the realm of pure physics to that of an electrical engineering problem. First application of this tube was in the cathode-ray oscilloscope. Television stimulated the development of the tube to the point where it made possible wartime radar. However, the cathode-ray tube is still in its infancy, and vast improvement may be expected.

PULSE ECHO MEASUREMENTS

"Pulse Echo Measurements on Telephone and Television Facilities," by L. G. Abraham (M '39), A. W. Lebert, J. B. Maggio, and J. T. Schott, all of Bell Telephone Laboratories, Inc., New York, N. Y., was presented by Mr. Abraham. An unusual application of the principles of radar to locate impedance irregularities, and control the quality in manufacture and installation of line facilities was described. The coaxial pulse echo set may be used to locate irregularities in coaxial lines, open lines, or spiral-four lines. The Lookator has a narrower band width and is used to locate gross troubles and irregularities in lines. After a description of the equipment and a discussion of the theory of operation, slides of several cathode-ray oscilloscope traces were shown. Tests were taken from both ends of a faulty coaxial cable, and the size, shape, and position of the echo "pip" were noted. From this it is possible to surmise the location and type of irregularities. It was pointed out that with this type of equipment intermittent irregularities, which escaped location by other methods, could be fixed. Discussion pointed out that the Institution of Electrical Engineers has published a paper on a similar application to power cables. It was found that the velocity of propagation changed at every joint, and therefore it was necessary to map the power cable to be tested. Mr. Abraham replied that he had had the same experience, except that impedances in general are better matched on telephone facilities than on power cables. A similar unit constructed for the Public Service Electric and Gas Corporation of New Jersey in which use was made of 1- or 2-microsecond pulses generated by capacitors was mentioned. The voltage of these pulses was not sufficient to arc the fault which it was attempting to locate. Multiple reflections were said to complicate the interpretation of results.

CATHODE-RAY COMPASS

A novel application of the cathode-ray tube was presented by W. H. Kliever and R. R. Syrdal, of Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., in this paper, "A Magnetic Compass With Cathode-Ray Sensing Element." Although developed as an airplane instrument, it no doubt will have many other applications. The cathode-ray tube is mounted vertically in gimbals to nullify the influence of the earth's vertical field. The horizontal component of the earth's field is used to deflect the electron beam. This deflection distributes the beam unevenly on four quarter-circle target plates. If there were no field, the beam would strike the juncture point of the four plates. To facilitate measurement and amplification, the cathode-ray beam is modulated in intensity at 400 cycles per second. Opposite pairs of plates are connected in push-pull, the output representing the difference in current between the plates, and being proportional to the component of magnetic field at right angles to the vertical line through the center of those plates. After component resolution to obtain the principal magnetic vector, the output may be fed to a servomotor indicating direction of flight, or to a directional gyroscope. If so desired, a negative feed-back arrangement may be used in connection with the directional gyroscope, which will tend to

eliminate the variation caused by the earth's vertical magnetic field when the airplane is banking. A demonstration was given of this compass; a knife with some residual magnetism was brought close to the tube, and the resulting deflection noted.

NULL DETECTION

Polarized a-c null detection was described in "Electronic Null Detectors for Use With Impedance Bridges" by H. W. Lamson (M '28) General Radio Company, Cambridge, Mass. The circuits which he described have greater sensitivity than those commonly used in a-c bridges. A resistive-capacitive negative feed-back amplifier is used to obtain this sensitivity. Elements are included in the circuit to attenuate all but the fundamental frequency to be tested, thereby minimizing the error due to harmonics. Results may be read on a cathode-ray oscilloscope, the amplitude of the minor axis of the ellipse formed indicating one of the quadrature components, and the major axis indicating the other quadrature component. At perfect balance a straight horizontal line will appear on the oscilloscope. A D'Arsonval-type galvanometer may be used to indicate either of the quadrature components. The component to be measured is selected by suitable switching of a phase shift network. The discussers pointed out that this network is of particular use in strain gauge measurements and that it will discriminate between tension and compression.

CATHODE-RAY SPECTROGRAPH

Rudolf Feldt (M '46) presented "The Cathode-Ray Spectrograph" written by himself and Carl Berkley, both of Allen B. DuMont Laboratories, Inc., Passaic, N. J. This spectrograph will investigate rapidly changing spectra and the results may be telemetered or transmitted simultaneously to several points. A mechanically resonant vibrating mirror is used to scan the spectrum and focus it on a photoelectric cell. The output of the photoelectric cell is applied to a conventional cathode-ray oscilloscope. Horizontal position of the image corresponds to the spectrum frequency, and vertical deflection is proportional to the light intensity. Changes in the spectral characteristics of the light source appear to be recorded instantaneously. This spectrograph is particularly applicable to production control. Demonstrations were given of the spectrum transmitted through a red filter, two blue filters, ink, and a rare earth.

Pratt and Whitney photo

Electronic instruments can gauge sheet metal at the tremendous rate of 6,000 feet per minute in this mill installation

Many Developments in Diesel-Electric Locomotives

A wide range of material covering control systems, a new 3,000-horsepower Diesel-electric locomotive, and dynamic braking was included in the session on Diesel-electric locomotives, at which W. A. Brecht (M '39) Westinghouse Electric Corporation, East Pittsburgh, Pa., presided. A factor mentioned in the discussion of the paper on the new locomotive was the low horsepower per ton, which was explained to give better riding characteristics and to improve track maintenance. Discussion on "A Power Plant Regulating System for Diesel-Electric Locomotives" mentioned the application of such control to well drilling rigs, paper mills, turbine drives, textile machinery, and aircraft power plants. "Developments in Diesel-Electric Traction Generator Excitation Control Systems" evoked extensive discussion concerning the relation of rail adhesion to generator load current limits. C. A. Brancke (A '41) who presented the paper, explained that in the system described the current limit is set above the point of wheel slippage.

LARGEST LOCOMOTIVE

Mr. Staples presented "3,000-Horsepower Diesel-Electric Locomotive for the Seaboard Air Line Railway," by D. R. Staples, Baldwin Locomotive Works, Eddystone, Pa., T. L. Weybrew and C. A. Atwell (M '43) Westinghouse Electric Corporation, East Pittsburgh, Pa. He described the shortest 3,000-horsepower unit yet available. The power plant consists of two 1,500-horsepower Diesel engines which drive direct-connected d-c generators. Each generator furnishes power to four traction motors, radiator fan motors, and traction motor ventilators. A factor which was stressed was the low weight per axle, which reduces track maintenance. The large number of axles also permits the application of eight traction motors, which results in a universal locomotive that can be used either in high-speed passenger service or heavy freight service.

The generators, which are of simple welded construction, have no series windings, but instead the battery-energized main field windings are used to furnish excitation during starting. Excitation for the generators is supplied by Westinghouse differential exciter systems. Automatic engine load control is provided by a governor-controlled carbon-pile rheostat, which varies exciter field resistance. Wide variation in engine power is permitted without overloading or underloading the engine. On this locomotive, auxiliary power is supplied by the main generator. Field shunting corrects for the variation of the generator speed. Smooth power application results from a modulated pneumatic throttle, and absence of motor connection transition, because all traction motors are connected permanently. The locomotive, has been in service for over a year.

LOCOMOTIVE CONTROL

"Developments in Diesel-Electric Traction Generator Excitation Control Systems," by C. A. Brancke (A '41) and G. M.

Adams (A '41) General Electric Company, Erie, Pa., explained a recently developed amplidyne excitation system utilizing saturable core reactors and selenium rectifiers to obtain definite generator fields in armature current limits. Used in conjunction with a speed sensitive power plant regulator it provides complete and flexible engine control over its entire operating range of speed and power. Maximum flexibility of motive power is provided by safe and complete remote control, which permits operating several units in multiple. Past control practice has depended upon inherent regulating characteristics of the electric generators, but use of larger and larger engines has dictated the need, which appears to be in direct proportion to the size of the power plant, for an external load regulating system, because this permits use of the minimum size generator with maximum permissible output under all conditions. The new system automatically regulates the excitation, providing optimum locomotive performance without exceeding maximum available engine power, maximum traction generator load current, and maximum traction generator field current. Such control permits closer approach to wheel slippage throughout the throttle range. This excitation control system comprises several features which result in improved performance as well as reduced maintenance and higher locomotive availability. These consist of engine protection, generator protection, controlled tractive effort, minimum size and weight of control devices, and reduced over-all maintenance.

DYNAMIC BRAKES

Attractive savings appear in lowered wheel and brake shoe maintenance and faster schedules which are provided by dynamic braking of Diesel-electric road locomotives as described in "Braking Resistors and Control for Diesel-Electric Locomotives," by E. F. Weiser, General Electric Company, Erie, Pa. Danger of a train running away on long mountain grades, owing to overheated brakes, is reduced to a minimum when the locomotive can absorb part of the power required to brake the descending train. Because no overhead system exists to which power can be returned a major problem is dissipation of the heat produced in the braking resistors. An air-cooled forced-ventilated design, which was produced because of the unavailability of cooling mediums on Diesel-electric locomotives, was described. The 74-horsepower fan motors are connected permanently in parallel with a section of the resistor, which is made up of 16 grids that may be removed easily. By forming each resistance strip into shallow V cross sections with adjacent strips, sufficient mechanical rigidity is attained, and the increased turbulence in the air stream passing over them materially increases the heat transfer. Some installations incorporate connections to the resistor, making it possible to load the generator for test purposes, which is an invaluable aid to the maintenance shop.

"A Power Plant Regulating System for Diesel-Electric Locomotives," presented by C. B. Lewis (A '44) General Electric Company, Erie, Pa., listed requirements of a Diesel-electric locomotive regulator, which include control of the power plant, multiple unit operation and remote control, and power plant protection. In order to provide full utilization of engine power over as wide a range of locomotive speed as possible, the generator characteristic must be altered to coincide with the engine characteristic over as wide a range of generator voltage as possible. Engine wear is a primary factor, and it is desirable to run the engine at the lowest possible engine speed commensurate with the power requirements set by the master controller. This makes it very desirable to schedule the engine fuel (torque) as a function of engine speed. The regulating system described comprises an engine-driven tachometer generator and centrifugal overspeed switch; an engine mounted regulator or governor; and an engine control panel. The flexibility of the system will facilitate future application to a wide variety of power plants.

Completion of new and larger Diesel engines in the years 1945 and 1946 for use in main line Diesel-electric locomotives has presented new control problems, in the solution of which many new developments in circuits, apparatus, and manufacture have been made according to M. D. Henshaw, General Electric Company, in his paper, "Developments in Control Systems for Diesel-Electric Locomotives." In the control system described amplidyne excitation is used. An interesting feature of the dynamic braking system is its stability, any tendency for the locomotive to speed up being counteracted by increased braking effort, without movement of the braking selector handle. Transition from series-parallel connections is accomplished through a 2-frequency system employing an axle-driven permanent-magnet-rotor a-c generator. Included in the description was the control panel lighting which utilizes ultraviolet radiation and fluorescent paint on the engraved markings and pointers. This "black light" illumination is not only pleasing to operators, but is a real aid to their adaptation to the dark.

Three Groups Compare Resistance Welding Problems

Five papers on various aspects of power supply for resistance welding were presented by representatives of utility companies and welder manufacturers at a conference session held, January 28 during the winter meeting under the chairmanship of C. N. Clark (M '45) of the Duquesne Light Company, Pittsburgh, Pa. The purpose of the conference was discussion of the problems encountered in providing proper power supply for resistance welders. Misunderstandings sometimes have arisen among welder manufacturers, utility companies, and the users of the equipment, and it was hoped that the discussion would be of assistance to the three groups.

Maintenance of machinery within AIEE for the co-ordination of the various viewpoints was advocated in order to avoid the possibility of another outside group being formed for this purpose. It was emphasized that the committee on electric welding is receptive to suggestions.

RATES FOR WELDERS

Following the presentation of the paper "Resistance Welding, a Beneficial Load," by Nathan J. Roberts (A '44) of the Ohio Public Service Company, Warren, Ohio, there was considerable discussion of the methods by which utility companies should charge customers for the special services installed in order to assure satisfactory operation of welders. The view was expressed that the technical problems can be solved, but that few utility companies have a sound approach to the problem of rates. Theodore Seely (A '41) of the Public Service Electric and Gas Company, Newark, N. J., outlined the policies of his company, which involve a charge to the user for extra facilities required, but provide for rebates, if other users later are added to the same facilities. The charge is made to cover the costs of the special facilities, not for the production of revenue.

In Mr. Roberts' paper, he pointed out that there are profit possibilities for the utility company in the welding business, and that it is to the best interests of such companies to establish carefully worked out rates and policies governing this class of service.

EQUIPMENT SELECTION

Speaking on "Application Engineer's Role in Insuring Adequate Power Supply for Resistance Welders," K. W. Ostrom, of the National Electric Welding Machine Company, stressed the importance of the application engineer, who is the first to be called in by the customer; he must understand the customer's problem, and serve as liaison agent with the supplier of power. The application engineer must reach a balance among cost of equipment, quality of weld, customer's needs, and available personnel for using the equipment. He then can recommend suitable equipment, give the customer necessary electrical data, supervise the installation, and perhaps assist in shop layout. Large users, of course, may have their own specialized personnel to perform some or all of these functions.

POWER SUPPLY AND VOLTAGE DIP

Practical methods of planning the power supply for resistance welding were discussed in papers by H. Watson Tietze (M '44) of the Public Service Electric and Gas Company, Newark, N. J., and by R. E. Young (A '38) and J. E. Rembusch (A '46) of the Public Service Company of Northern Illinois, Kankakee. Allowable voltage dip was seen to be determined largely as a matter of experience, but it seemed generally agreed that less than 10 per cent of welder installations are troublesome.

Dissemination of information was held to be one matter on which action is required both among all utility companies and within each company. Instances were cited of companies adhering to obsolete and unnecessarily restrictive standards for the addition of new equipment to the line, and

of minor employees in progressive companies who adhere blindly to general rules, although higher company officials, if they could be reached, readily would grant exceptions. In extreme cases these conditions may be a hardship to customers and result in the installation of unnecessary equipment.

Second National Servomechanisms Session

An indication of the general attitude and interest shown at the technical session on servomechanisms January 28 at the winter meeting is the fact that approximately 300 engineers attended this session and many stood throughout the 3-hour meeting. The servomechanisms subcommittee was formed one year ago, and this was its second session. G. S. Brown (A '33) associate professor of electrical engineering at Massachusetts Institute of Technology, Cambridge, who is chairman of the servomechanisms subcommittee, presided.

The papers read all were closely integrated in subject matter. One considered important techniques in the synthesis of system performance; two others dealt in detail with the technique used in design and performance; and the final paper described how design problems are tackled in the laboratory "breadboard mockup."

SINUSOIDAL ANALYSIS

The first paper to be presented, "The Application of Lead Networks and Sinusoidal Analysis to Automatic Control System," was by George J. Schwartz (A '46) of the Arma Corporation, Brooklyn, N. Y. The paper demonstrated the improvement in a d-c motor control system that may be achieved through the use of output feedbacks and one type of anticipatory network. Only the mathematical preliminaries to the analysis of a control system, which is valuable in predetermining quantitatively a control design, were considered. After the transfer function is derived, the physical constants of the system are evaluated by calculation or measurement. Completion of these steps is followed by sinusoidal analysis to detect the effect of the individual components and control effects on the over-all system response.

ANALYSIS BY ANALOGY

The mechanical transients analyzer has provided a ready method for making generalized studies of the response characteristics of servomechanisms. Actual physical systems and the equations defining their performance were presented in the paper of G. D. McCann (M '44) of California Institute of Technology, Pasadena, Calif., and S. W. Herwald (A '46) of Westinghouse Electric Corporation, East Pittsburgh, Pa., entitled "Dimensionless Analysis of Servomechanisms by Electric Analogy—Part II," together with the electrical analogies set up on the analyzer. Once the original problem has been set up, the "juggling" of different parameters to get the most desirable system, one that will meet customer specifications, simplifies the designer's problem.

COMPARISON OF BASIC TYPES

"A Comparison of Two Basic Servomechanism Types" by Herbert Harris (A '46) of Sperry Gyroscope Company, Inc., Great Neck, N. Y., analyzed and compared servomechanisms with lead network stabilization and those with speed feedback through a high-pass filter. The method of analysis is on a frequency response basis using inverse transfer functions. Detailed design tabulations are presented along with the limitations imposed by response delays. Analysis of motor suitability for these servomechanisms shows that torque-inertia ratio is a poor quantity for a figure of merit, and several alternative ratios are shown to have more value.

Doctor T. F. Ball (F '38) of the applied physics laboratory at Johns Hopkins University, Baltimore, Md., made several interesting suggestions concerning the papers of McCann and Herwald, and Harris. He stressed the necessity for ruggedness and over-all time constants, pointing out that, although a design on paper may look satisfactory, quite often it will not meet the stringent tests of a moving laboratory. He asked the designers of servomechanisms to deal with design for high velocity and acceleration. "Build them about the size you can fit into your vest pocket," he told the men interested in this field. Discussion brought out that different units were used for moments of inertia in the three afore-mentioned papers. The possibilities of the antilog method in design were suggested.

LABORATORY AIDS FOR DEVELOPMENT

The final paper on the program, "Laboratory Aids for Electromechanical System Development," by George C. Newton, Jr. (A '31) and W. T. White, both of Sperry Gyroscope Company, Great Neck, N. Y., was read by Doctor White. Standardized components used by Sperry engineers for mocking up electromechanical systems were described. Once the initial investment has been made, complex systems may be mocked up rapidly at small costs. The components save much engineering time by making it possible for technicians to maintain and service units. Standardization of mockup component parts eliminates the necessity for repetitious design. When a mockup has served its purpose, it may be disassembled and the parts returned to stock for further use.

At the conclusion of the session Professor Brown pointed out that the designs presented are important not only to the electrical engineer, but also to all those interested in the fundamental problem of analysis and synthesis of controlled cycle systems, namely, the electronics engineer, the mechanical engineer, and the basic scientist, and that there is no one unique way of attacking the problem of design of servomechanisms.

Camera and Receiver Demonstrations Given at Television Session

C. B. Jolliffe (M '34) of Radio Corporation of America, Princeton, N. J., opened the session on television on January 28 by announcing that because of a Federal Communications Commission hearing at the United States district courthouse the facilities of *WNBT* (National Broadcasting Company television station) would be devoted primarily to the exhibition necessary for this, and that certain demonstrations which had been planned for the AIEE meeting might have to wait. Television is a subject of live interest to electrical engineers as a means of communication and as a user of power. The whole television system should be considered as a unit, main parts of which were considered by separate papers.

BROADCAST EQUIPMENT

"Television Equipment for Broadcast Stations," by Walter L. Lawrence (A '30) Radio Corporation of America, Camden, N. J., discussed the various equipment necessary for television broadcasting and the equipment available in commercially "product designed" models (equipment that is produced in quantities to the same carefully engineered design). This includes studio equipment and transmitting equipment. Studio equipment, which utilizes video frequencies, includes cameras, camera control units, synchronizing signal generators, video amplifiers, associated video switching equipment for multicamera operation, stabilizing amplifiers, and auxiliary equipment. Studio lighting equipment is, and probably will continue to be, much the same as that used in photographic studios. The various cameras can be divided into four general classifications: network, film, remote pickup, and studio. The simplest of these, the monoscope camera, produces a set test pattern, which is used for qualitative measurements of equipment. The television film camera produces video signals from motion picture images projected upon its pickup tube. Field cameras are designed for compactness and portability and generally employ the Image Orthicon pickup tube. A monitor image is furnished to facilitate focusing of the camera. The covers of field cameras were taken off to demonstrate the "inside out" construction, whereby usually inaccessible points were brought to the outside for convenient maintenance. Switching equipment for the cameras, a master monitor system, and a complete audio switching inter-

communication system is included in the control panel. The stabilizing amplifier is used at the input of the visual transmitter to minimize transient disturbances that may be introduced by the switching process. A television transmitter which covers 12 of the present 13 television channels assigned by the FCC is divided into eight racks for ease of operation, inspection, maintenance, convenience in shipment and installation, and economy in manufacturing. A superturnstile antenna is available in three styles, one of which may be operated on each of the 13 channels. The diplexer and its associated bridge network enables both the aural and visual carriers to be radiated by the same antenna. Television may prove to be an important aid in process control. Tremendous optical magnification of small objects may be transmitted from remote or inaccessible locations to a convenient central observation post and relayed to control points. Entire presentation of this paper was photographed by an Image Orthicon camera and projected by five television receivers distributed throughout the audience. The author demonstrated many of his points in an interesting fashion throughout the presentation. Various lenses available on a field model of the Image Orthicon and their rapid accessibility were shown.

RECEIVER DESIGN

D. W. Pugsley (A '36) of General Electric Company, Bridgeport, Conn., in his paper, "Postwar Television Receiver Design," described and demonstrated many new design features and characteristics of television receivers. Circuit refinements necessary to eliminate interference with other receivers were described. If not eliminated, this interference might extend up to one mile. The high-voltage supply circuits, which are used to supply 6,000 to 30,000 direct potentials without danger to the user, were of particular interest. A projection-type receiver demonstration in the form of a *WNBT* broadcast of a newsreel and two gypsy dancers was given. Essential substance of this paper is given on pages 249–53 of this issue.

"Color Television Receivers," by P. C. Goldmark (M '45) and G. R. Tingley of Columbia Broadcasting System, New York, N. Y., was presented by Kurt Schlesinger also of CBS. He stated that color television would be similar in many ways to the present black and white television. The scanning frequency will have to be 144 lines per second, and the video band width will be approximately 10 megacycles with carrier frequency in the neighborhood of 100 megacycles. Directional antennas, capable of operating over a wide band width, will be used to take advantage of their high gain and reduce the side frequencies and ghosts. A single-side-band receiver will separate by appropriate methods the audio signal which will be pulsed and interleaved with the video signal. However, a separate carrier may be used for the sound signal. The color drum or disk will be driven by a fractional-horsepower motor controlled by a comparison-type circuit, which effectively corrects phase error without hunting. A 30-volt variation in line voltage is permissible. Over-all efficiency of the unit will be increased by a method of reclaiming approximately 30 per cent of the deflection circuit field energy. The picture on the 10-inch kinescope will be viewed through an optical system with a magnification of 1.2.

TRANSMISSION SYSTEMS

J. F. Wentz (M '42) presented his paper, "A New Microwave Television System," written with K. D. Smith, both of Bell Telephone Laboratories, Inc., New York. Coaxial cables probably will remain the backbone of the television system, but radio relay equipment has proved itself to be invaluable for use over mountainous or inaccessible terrain and for temporary installations. A microwave frequency-modulated system has been developed. Mr. Wentz presented many interesting design data of this system.

The more general paper, "Television Network Facilities," by L. G. Abraham (M '39) of Bell Telephone Laboratories, Inc., New York, and H. I. Romnes (A '41) of American Telephone and Telegraph Company, New York, was presented by Mr. Abraham. Short haul television circuits can use microwave radio relays, a special balanced pair, or coaxial cables. It is of interest to note that on January 27, the day before the presentation of the paper, a color demonstration was given for the FCC over existing network facilities from Washington to New York. Long haul television can be by radio relay or over coaxial systems of the type originally developed for carrier telephone circuits. The most important technical considerations of a network for the transmission of television pictures are the usable frequency bands, echoes and gain in phase deviation, noise, modulation, and cross talk. These characteristics were discussed thoroughly by the author.

Solutions Presented for Transformer Protection

The acute problem of transformer protection was examined at the technical session on power relays, January 28, presided over by W. R. Brownlee (M '38) of the Commonwealth and Southern Corporation, Jackson, Mich.

In "Simplicity in Transformer Protection," Eric T. B. Gross (M '40) professor of power systems engineering at the Illinois Institute of Technology, Chicago, Ill., reviewed both American and foreign experience and practice with gas-actuated relays for the protection of power transformers. Doctor Gross advocated the increased use of the gas-actuated relay, because it is a simple and economic protective device which can be applied to special transformers for which other devices are complicated, expensive, and of very reduced sensitivity with limited protective value. F. C. Lawson (M '42) of Halifax, Nova Scotia, Canada, discussed Doctor Gross's paper, reporting favorable experiences of Canada in the use of this type relay. Mr. Lawson believed that this type of protection is the most sensitive and reliable for transformers. Other discussers experienced in this field also substantiated Doctor Gross's and Mr. Lawson's comments.

SUBCOMMITTEE REPORT

The AIEE relay subcommittee has reviewed current problems and thoughts on grounding of instrument transformer secondary circuits for the purposes of disclosing shortcomings in certain methods and recommending preferred processes. The report, "Grounding of Instrument Transformer Secondary Circuits," outlined the practices followed in the companies of the reviewers, described adverse experiences encountered, and presented opinions on the subject. Recommended preferred practices were the sum total of this investigation.

REVISED PAPER

"Fundamental Basis for Distance Relaying on 3-Phase Systems," by W. A. Lewis (F '45) and L. S. Tippett, both of the Illinois Institute of Technology, Chicago, Ill., originally was presented at a District meeting in 1931. This material has been so utilized over a period of years, especially recently, that its authors were asked to bring the material up to date for publication, to supplement the present references.

Three full years of operating experience with single-pole switching on five 132-kv transmission lines, totaling 331 miles in length, was presented and analyzed in "Experience With Single-Pole Relaying and Reclosing on a Large 132-Kv System," by J. J. Trainor and C. E. Parks (M '45) both of the Public Service Company of Indiana, Inc., Indianapolis. In his presentation Mr. Parks traced the location of the installation of this system throughout Indiana, describing the various types of protective relays used. Operating experience was summarized in a table, the analysis of which showed that there was a total of four unsuccessful 3-pole circuit breaker reclosing operations on five lines for the three years covered by the report. During the past three years, invaluable operating experience has been accumulated in the use of single-pole high-speed reclosing of 132-kv transmission lines on a large interconnected power system. Single-pole reclosing has all the advantages that are to be realized by the use of 3-pole reclosing and, in addition, possesses a number of advantages not yet enjoyed by the latter speed.

Recent Developments in Meters and Measurements

T. S. Gray (F '45), Massachusetts Institute of Technology, Cambridge, Mass., officiated at the technical session on instruments and measurements which included a demonstration of air-borne magnetometer equipment. There was some discussion concerning the use of sphere gaps as precision devices in the measurement of high

voltages, which was stimulated by the paper on calibration of ignition crest voltmeters. Other papers included material on various types of meters and the measurement of high Q cavities at 10,000 megacycles.

AIR-BORNE MAGNETOMETER

Air-borne magnetometers developed during the war for the detection of submerged enemy submarines since have become important tools for aerial geophysical exploration as explained by E. P. Felch (M '39) who presented "Air-Borne Magnetometers for Search and Survey," of which he was co-author with W. J. Means, T. Slonczewski, Bell Telephone Laboratories, Inc., New York, N. Y.; L. G. Parratt, Cornell University, Ithaca, N. Y.; L. H. Rumbaugh, Naval Ordnance Laboratory, Washington, D. C.; and A. J. Tickner, Western Electric Company, Inc., Hollywood, Calif. Operation High Jump, better known as the Byrd Antarctic Expedition, is utilizing the magnetometer in its explorations. The instrument utilizes the second harmonic outputs produced by the magnetic field in saturated core inductors for field measurement and control of servomechanism stabilizing systems acting around two axes to maintain the measuring element in alignment with the earth's magnetic field. Mr. Felch conducted a demonstration showing how the apparatus output was affected by a varying magnetic field. In magnetic surveys carried out on the ground, mapping of an area has involved correlation of a multitude of discrete measurements at accurately spaced stations, which covered approximately 1½ square miles per day in favorable terrain. The United States Geological Survey and the Naval Petroleum Reserves have been able to cover as much as 1,000 miles of contour per day with an air-borne device.

The method of detection consists of placing in the field under investigation an open core of high permeability and easily saturable magnetic material, and superimposing on the unknown field a sinusoidal magnetomotive force large enough to saturate it. The electromotive force produced by variation of flux is analyzed by an electronic circuit. Length of the core is such that magnetic noise caused by uncontrollable motions of the inductor in the earth's field and the motion of nearby magnetic objects is somewhat larger than the electronic noise in the detecting circuit. The circuit to which the inductor is connected consists of 1,000-cycle oscillator which feeds the driving current to the inductor through a filter eliminating all other frequency components. Orientation of the inductor is of major importance, because the incremental variation of magnetomotive force to be measured is usually small in comparison with the total of the field. Output of two of the three inductors is utilized by a servomechanism which maintains the detector inductor parallel to the earth's field. To overcome this difficulty through motion of the inductor unit, three inductors can be mounted with their axes in an orthogonal system, and there outputs can be squared electroncially to produce an indication proportional to the energy of the field, this indication being independent of the position of the axis and therefore of the position of the system.

CREST VOLTMETER CALIBRATION

In studying the performance of aircraft and automotive types of internal combustion engine ignition systems, ignition crest voltmeters have been used for the measurement of peak voltages at various points in the systems. In view of the inconsistent performance of the meters, a study was undertaken in which several of the factors influencing the performance of the various available instruments were segregated and analyzed separately as described in "The Calibration of Ignition Crest Voltmeters," by W. L. Davis, Battelle Memorial Institute, Columbus, Ohio, and C. E. Warren (A '41) Ohio State University, Columbus.

One of the first factors considered in the study was the wave shape of the voltages to be measured. A study of the oscillograms obtained revealed that the most frequently recurring wave form is one which rises sharply to a peak and then is chopped off as the spark plug gap arcs over. These wave forms immediately suggest that a surge generator of the type used for testing power system equipment would be a suitable device for testing. Accuracy of calibration of the crest voltmeters depends on an accurate determination of the peak output voltage of the surge generator. Application of these spark gap circuits to the calibration of ignition crest voltmeters has resulted in a better understanding of the various factors influencing meter performance.

LONG SCALE METERS

Experience gained in the last few years has pointed the way to certain design improvements in long scale indicating instruments as shown in "Advancements in the Design of Long-Scale Indicating Instruments," by R. M. Rowell (A '42) and N. P. Millar (A '44) General Electric Company, West Lynn, Mass. Among the accomplishments achieved have been the improvement in general appearance and ease of reading, ease of calibration and adjustment, better accuracy under abnormal conditions, and simplification of recalibration.

Scales of the meters have been made to encompass over 200 degrees, which has made possible reduction in size of the meter body. In the new design, the two different repulsion irons for ammeters and voltmeters are shaped to give the scale distribution which produces a greater torque gradient over the low end of the scale. Another feature of the mechanical design, which will aid greatly the servicing of these instruments, is the ability to withdraw the moving system without disturbing the field and coil assembly which is permitted by a hook-shaped section of the lamination assembly.

HIGH FREQUENCY MEASUREMENT

"Measurement of High Q Cavities at 10,000 Megacycles" was presented by R. W. Lange, Bell Telephone Laboratories, Inc., New York, N. Y. The significant feature of the wide range heterodyne decrement method of measurement of values of Q above 30,000 at above 3,000 megacycles is that the accuracy is improved by observing the decay over a relatively long interval of time and an absolute accuracy of ± 3 per cent is achieved. The pulse from the ultrahigh frequency oscillator is applied as a signal to the cavity under test. Decay of energy within the cavity after the signal pulse has ceased is observed through a heterodyne detector circuit ending in an oscilloscope which is used as a comparative and not a measurement tool. For measurement of resonant cavities it is possible to procure the signal frequency by beating a fixed centimeter oscillator with a calibrated variable frequency signal generator in the 50-megacycle region or lower. The method is applicable to all forms of 4-terminal electric networks.

DEMAND METER

"A Polyphase Thermal Ampere Demand Meter," by A. J. Petzinger (M '44) Westinghouse Electric Corporation, Newark, N. J., pointed out that kilovolt-ampere demand long has been one of the quantities which often is involved in billing a consumer for electrical service. Recording meters and indicating demand meters are available which measure true kilovolt-ampere demand, and their use is justifiable on large loads. On smaller loads, however, their use may be uneconomical. One answer to the problem is the thermal kilovolt-ampere demand meter employing the displaced voltage principle. Accuracy is reasonable if the meter power factor is close to the load power factor. The paper presented by Mr. Petzinger approached the problem of small kilovolt-ampere demands through the indication of a thermal ammeter. In the usual thermal ammeter deflection is proportional to heater resistance. In this instrument an unheated bimetal spring opposes the heated spring, thereby cancelling most of the ambient temperature errors in the springs. Further compensation is accomplished by use of heater material with a slightly positive temperature coefficient. The scale of the meter has a basically squared distribution and can be calibrated in amperes, or for a given voltage, in kilovolt-amperes. The use of an assumed voltage for kilovolt-ampere indication perhaps will be looked upon with some disfavor, but relatively low cost should offset other disadvantages.

Four Papers Presented at Resistance Welding Session

Resistance welding was the subject of a technical session held January 28, under the chairmanship of G. W. Garman (M '43) chairman of the AIEE electric welding committee. Though electrical engineers have been interested in resistance welding for relatively few years, a number of papers on the subject have been presented during that time. Through the efforts of the Resistance Welding Manufacturers Association, machines and controls have become standardized. Thus the RWMA and the National Electrical Manufacturers Associa-

tion through their standards work have contributed to the solutions of general problems, but on other problems little information is available.

VOLTAGE VARIATION

The paper, "Voltage Changes Due to Resistance Welding Loads," by I. B. Johnson (M '45), H. A. Peterson (M '41), and C. M. Rhoades, Jr. (A '44), General Electric Company, Schenectady, N. Y., was presented in answer to the many questions which have been raised regarding the effect of resistance welding machine loads introducing voltage changes in the system supplying power to the welders. An attempt was made to remove questions by measuring and expressing quantitatively a welding system in miniature. Data were presented, largely in the form of curves, relating to the effects of various types of welding loads. A great deal of interest was aroused by this paper, particularly in the effect of a power-factor-corrected single-phase welder as compared with the effect of a 3-phase welder on power supply. The conclusion was reached that the results are comparable and depend upon welder circuit constants.

WELDER THROAT VOLTAGE

The paper, "The Voltage Drop in the Welder Throat Loaded With Ferromagnetic Materials," by G. M. Stein (M '38) of the Westinghouse Electric Corporation, Sharon, Pa., presented a mathematical analysis based on a calculation of the influence of the welding materials on the field and voltages of the welder throat, and compared the computed values favorably with obtainable test results. Discussers agreed that Mr. Stein's analysis is a valuable contribution to the field of resistance welding.

WELDING TOOL CHARACTERISTICS

"Electrical Characteristics of Resistance Welding Tools," by E. M. Callender (A '35), The Budd Company, Philadelphia, Pa., discussed methods of measurement and calculation to determine characteristics of resistance welding tools, particularly for the large group of nonstandard-type portable welding guns. The ground work for calculating inductance, as described in this paper, is based on the simple theoretical case for an infinite pair of lines. With that consideration suitable correction factors then are developed as required for the various special problems encountered with welding tool configuration. In his discussion of this paper I. B. Johnson agreed that, though this method is not quite so satisfactory as others, it is valuable for the calculation of impedance for equipment about which nothing is known but its geometry.

FUNCTIONAL CONTROL

The final paper of the session, "Functionalized Resistance Welding Control," by C. B. Stadum (A '43), W. E. Large, and E. C. Hartwig, all of the Westinghouse Electric Corporation, East Pittsburgh, Pa., was concerned with some of the redesigned welding control circuits in the modern line of welding controls. The paper was presented by Mr. Stadum, who stated that the result of controlled modernization is functionalized welding control. This control is based on the fact that, by designing new circuits for welding controls with each major function capable of being physically separated from other functions, it has been possible to assemble panels of the functions in enclosures which increase the versatility and serviceability of the control. It thus is possible to replace old controls, or substitute or add new control functions, with a minimum of effort. In a discussion of the paper the fact was brought out that the controls described by Mr. Stadum were designed according to NEMA standards. Chairman Garman emphasized the importance of these standards for resistance welding controls (which probably are the first steps in standardization of controls) as an indication of progress in resistance welding.

Trends in Industry Use of Quality Control Discussed

Two distinct phases of the application of statistical methods to quality control—the first effecting an improved product design and the second an improvement of manufacturing and assembly processes—were described at the conference on statistical methods held on January 28 during the winter meeting. W. P. Dobson (F '43) chairman of the AIEE Standards committee, presided at the conference, which was a joint one with the American Society for Quality Control. It also was the first such conference on a national scale in which the ASQC had participated.

Mr. Dobson outlined briefly the 3-year history of the AIEE subcommittee on statistical methods and mentioned the series of educational articles on the subject which the subcommittee is sponsoring currently in *ELECTRICAL ENGINEERING.*

ASQC OBJECTIVES

Speaking on "The American Society for Quality Control—Its Objectives and Its Progress to Date," G. D. Edwards (M '26) of Bell Telephone Laboratories, Inc., and president of the ASQC, analyzed what industry could expect to gain from quality control, and the standing which its proponents were endeavoring to achieve for quality control, and proceeded to explain the consequent need for a national society to promote these ends.

Mr. Edwards offered as a simplified definition of quality control, "a scientific arrangement of inspection procedures." The scientific arrangement of procedures, he continued, should be sound scientifically, mathematically, and statistically, and practical and realistic in terms of dollars and cents. Finally it should supply definite answers to such questions of procedure as:

1. Where, how, when, and how much sampling should be done.

2. How results should be analyzed, that is, what should be done with the samples and with substandard items.

In the word inspection in his definition, he included operation and testing as well as visual and manual inspection, and his ideal inspection would entail a minimum of testing, a minimum of rejections, and a maximum of delivered units.

Mr. Edwards drew a line of demarcation between the mathematician and the statistician and the quality control expert based on their concepts of perfection. The latter, he said, was interested in a practical workable perfection which can be translated into profitable production and not in the theoretical perfection of the former two.

This he later advanced as one of the reasons for the founding of ASQC as an independent society rather than an affiliate of existing statistical organizations. Besides bringing the disadvantage of submergence in an organization with primary interests in another field, such an affiliation would lead quality control men away from practical problems, he said. An independent ASQC also has the important advantage of supplying an outlet for an existent interest, whereas, introduced into existing societies, the subject of quality control is usually in the position of being promoted from the top down.

The purposes of ASQC, as summarized by Mr. Edwards, are to gain for quality control professional standing, to provide a medium for the dissemination of information on latest advances in methods through *Industrial Quality Control,* and to provide opportunity for interchange of ideas through regional and national meetings. The society hopes to develop recognition of statistical quality control as a foundation stone in a sound industrial economy, to effect standardization of procedures and minimum qualifications, and perhaps to draw up a code of ethics. The society has developed as a federation of 25 local societies which sprang into being first.

CONSUMER GOODS STUDIED

In "Statistics Applied to Consumer Goods," E. E. Folsom, Jr. (A '46) of the General Electric Company, Bridgeport, Conn., presented a statistical study of an automatic electric toaster which led to a change in the size of the timing slot and a change in buying practices for a bimetal component.

Before the changes were effected, the production record of the toaster showed 60 per cent rejects during manufacture and a rework score of 60 per cent of the completed units. The study was completed during a strike period, and the first 200 toasters produced after an 8-week layoff were 92 per cent effective. The original problem was that of securing from the toaster in the shortest possible time even performance at the end of each complete cycle of heating up to toast one slice of bread and cooling down to be ready to toast the next slice.

The dispersion of a sampling of toasters within the limits of performance specifications first was obtained. The working of the apparatus next was broken down into four movements, and a correlation study of the effects of the characteristics of distance moved, variations in the bimetal, and current used was made, and the characteristics analyzed as percentages of the whole process. However, for economic reasons,

changing the current could not be employed as a means to better performance. It was discovered that, in one half the cycle, distance was of major importance, and in the other half cycle, the quality of the bimetal dominated, and the changes previously mentioned were made.

STATISTICAL TOOLS

As it spread through industry under the war impetus, statistical methods of quality control are most commonly used in inspection departments, A. J. Winterhalter, of the Colonial Radio Corporation, said in introducing his subject, "Application of Statistical Methods in Industry."

The basic fact behind the acceptance of statistical methods is that an adequate sampling is more effective than 100 per cent inspection, because of the greater importance of the human factor in 100 per cent inspection.

He distinguished two kinds of inspection of samples: that in which the characteristics of the samples can be measured along a continuous scale, and that of mere visual inspection requiring a simple judgment of good or bad.

Where measureable characteristics are concerned, standard and average deviation from the norm can be calculated, correlation studies can provide a simple test as a substitute for a more costly one, and trends can be studied. Good correlation between time of testing and the amount of trouble that can be expected also is noted in experience with radios.

Establishment of proper control charts for a product produces results by fact control rather than by laboratory control, he said. It is then possible to determine in advance, the number of analyzers needed for production control. Sampling results also can be used to help in grading personnel or in shifting personnel for maximum efficiency, he pointed out.

CURRENT PROBLEMS

During the discussion period, Doctor P. S. Olmsted, of Bell Telephone Laboratories, Inc., Murray Hill, N. J., speculated that perhaps, in analyzing design and inspection procedures, manufacturers were neglecting an important factor in not giving more attention to public opinion polling, another statistical method. The improvements in quality effected by a manufacturer may not always be those most desired by the ultimate consumer, he said, and urged greater co-operation between the scientific and opinion polling groups. Another undeveloped field which should benefit from statistical methods, according to Doctor Olmsted, is research and development. Order statistics would figure prominently here, he thought.

Caution in depending on public opinion was advised by Mr. Edwards, who hazarded the opinion that one half of the time the public can not be expected to know what it wants. The manufacturer, in his opinion, usually is a better judge of a market situation.

P. L. Alger (F '30) of the General Electric Company, Schenectady, N. Y., predicted an expanding future for quality control. He foresaw the steady conversion of opinions to numbers in manufacturing processes, as more and more come within the scope of quantitative analysis. As an example of future uses of statistical methods, he mentioned "A Sampling Procedure of Design Tests of Electron Tubes," as the precursor of the incorporation of such procedures in test codes.

An inquiry about whether statistical studies had been made on the sort of maintenance a product might require elicited the opinion that no such studies had been undertaken, though several of the conferees agreed that there is a need for them.

Mr. Dobson introduced the question of methods of controlling the quality of purchased material.

Mr. Winterhalter replied that random sequential sampling usually provided desired results in determining the number of defects that could be tolerated as a basis for rejection. When this procedure showed consistently good results, the method of sampling was varied.

Doctor J. G. Gaillard, of the American Standards Association, asked whether the practice of requesting information from suppliers on their quality control methods, or of asking for the submission of control charts, is at all established.

Mr. Parker mentioned the practice of showing the supplier the purchaser's charts on the former's product, which has been initiated in some companies. One recognized objection to showing a customer, a manufacturer's control charts, he said, is that such charts are not developed equally for all products, and the customer tends to expect this. He also mentioned the practice of requiring the supplier to do sampling in accord with a purchaser's methods.

A. B. Mundel (M '44) of the Sonotone Corporation, stated that interchange of quality control information is particularly helpful when the factors checked by the manufacturer may not be those of most concern to the purchaser. This would not be true, however, where products are made to specification.

Mr. Folsom made the point that engineers have a long way to go before they are able to describe exactly what is intended. In essence, he said, quality control is knowledge of the characteristics of a product and means looking at more units than ever before. The purchase order of the future, he predicted, would include a sampling plan as a matter of course, as well as the present legal statement and engineering drawings.

Mr. Hecht supported the contention that engineers do not know the variable characteristics of their products. He also advocated the practice of including the pertinent American Standard with an order. P. C. Clifford of Montclair, N. J., revealed that one company is introducing the use of a joint control chart upon which acceptance of an order is based. Doctor Gaillard cited ASA experience with its three war standards on quality control.

Energy Sources for Electric Power Explored

Recent developments in nuclear energy have given impetus to new methods of supplying electric power and have led to the sponsorship by the AIEE committee on basic sciences of a series of conferences on methods of producing electric power and to the establishment of a subcommittee to investigate energy sources under the chairmanship of W. A. Lewis (F '45) of the Armour Research Foundation, Chicago, Ill. The first conference was held January 29 during the winter meeting with J. D. Tebo (M '36) chairman of the committee, presiding. An audience of more than 500 was present.

Production of electric power from atomic energy itself, however, was not considered at this session, except as it entered into the discussion of electrostatic phenomena as mentioned hereinafter. Of the many other means of generating electric energy only three, namely, emission phenomena, piezoelectric phenomena, and electrostatic phenomena were treated in papers presented at this conference.

PRODUCTION OF ELECTRIC POWER

"A Survey of Methods of Producing Electric Power" was presented by L. W. Matsch (M '41) of the Armour Research Foundation, Chicago, Ill., in which he listed 11 means: electromagnetic, thermoelectric, electrostatic, electrochemical, piezoelectric, contact electricity, emission phenomena, pyroelectric, magnetostriction, atmospheric, and earth potential. The first is the one of principal importance by far, and may be separated into many subdivisions. In compiling the various classifications of electromagnetic generators, existing definitions for machines were found to be incomplete.

EMISSION PHENOMENA

The flow of electric current from a solid body to a rarefied atmosphere was presented from the point of view of a physicist by L. A. DuBridge, president of California Institute of Technology, Pasadena, Calif. Emission phenomena may be of thermionic, photoelectric, or so-called secondary origin, and, although the power involved is small, its applications are extremely important. According to present theories, the electrons in any given mass of substance are at different but discrete kinetic energy levels with not more than two electrons in the mass at any one level. Two electrons can exist at the same level, only if the directions of their spin are opposite. Maximum energy of

the electrons, regardless of the size of the material, is thought to be ten electron volts. The substance retains its physical form, because a barrier at its boundaries requires a higher energy than ten electron volts for the electrons to escape. This energy may be given to some of the electrons, however, by heating, by the application of an electric field, or by bombardment with positive ions. It can be shown that in electron tubes a very small amount of thermal energy is converted to electric energy in the cathode. The conversion efficiency, however, is very low.

The use of light to raise the energies of electrons to the point where they can escape from the surfaces of the material is seen in the photoelectric effect, which was the first point at which the electromagnetic theory of light broke down. The energy of escaping electrons is independent of light intensity, and the quantum theory results in a simple relation for explaining the escape of electrons. Photoelectric phenomena are independent of temperature in the usual range. By the addition of secondary emission phenomena, as now applied in television tubes, great amplification may be added.

It is possible for electrons to escape through a potential barrier in which they have negative energy, but this anomaly still is in accordance with the quantum theory.

PIEZOELECTRIC PHENOMENA

Explaining that certain crystals may be considered as capacitors, motors, and generators, Doctor Walter G. Cady, professor of physics at Wesleyan University, Middletown, Conn., discussed their properties leading up to a fictitious use as a source of power. Some substances have the property of varying electric potential with stress, but at the present time only crystals are of practical importance. Placed between electrodes, a crystal exhibits the characteristics of a series resistance, capacitance, and inductance, the resistance and capacitance being low and the inductance very high.

An atomic theory of piezoelectricity, as electricity resulting from pressure is called, is in an infantile state. Quartz and Rochelle salt crystals now are used, but the latter has the disadvantages of being subject to dessication and failing at high temperatures. New substances are being studied for use as the known supply of quartz diminishes. The development of large amounts of power from crystals by piezoelectric phenomena is very remote according to Doctor Cady. A brief flash may be obtained from a neon lamp connected to a Rochelle salt crystal when the crystal is struck, but supplying 1 ampere to a 100 ohm lamp at a frequency of 60 cycles per second would require 1,500 square feet of quartz crystal area, which could be arranged in a pile one foot square and subjected to a pulsating force of 100 tons.

ELECTROSTATIC PHENOMENA

Possibilities of the use of electrostatic phenomena in place of electromagnetic phenomena in electric machines were foreseen by John G. Trump (A '31) associate professor of electrical engineering, Massachusetts Institute of Technology, Cambridge. These phenomena were the first ones in electrical science to be observed and have been reported in experiments over a period of many centuries. Interest in electrostatics now has been rekindled by the need for high energies in nuclear studies. Practical generators providing potentials as high as five million volts now are usually of the Van de Graaff type, in which a moving belt of insulating material carries a charge to an insulated terminal. A belt one foot wide moving 6,000 feet per minute can transmit enough charge to permit a direct current discharge of 1/2 milliampere continuously.

Insulation is the principal factor limiting electrostatic machines. High vacuums and gasses under pressure now are used. A dielectric strength of 400 kilovolts per inch is obtained in a modern two-million-volt generator operating under pressure and used to supply high voltage for an X-ray tube. Voltage ratings of such generators are increased by improving the insulation, and solid insulations have been developed with strengths of three million volts per foot. Studies are in progress on the mechanism of high-voltage breakdown and have led to the proposal that in vacuum there is an interchange of charged particles between surfaces.

Motors and generators employing electrostatic sources were said to offer attractive possibilities. The force between plates, having an area of 100 square inches and in high vacuum with a gradient of three million volts per centimeter, is 5,700 pounds. Machinery would be of inherently high efficiency, because operation in vacuum would eliminate windage losses, and the small current resulting from the use of extremely high voltages would result in small resistance losses. There would be no magnetic losses. It was suggested that with a voltage gradient of one million volts per centimeter a 7,000-kw machine could be built within physical dimensions of 10 feet by 16 feet.

Future employment of electrostatic machines for the utilization of atomic energy was foreseen. If radioactive isotopes having energies of one million volts could be produced, the electrodes of an electrostatic motor could be brought to the energy level of the particles. The energy then could be converted to mechanical power and utilized directly without a heat cycle.

Industrial Control Devices Presented

The technical session on industrial control devices on January 29, attended by approximately 100 engineers, was presided over by E. U. Lassen (M '33) of the Cutler-Hammer Company, Inc., Milwaukee, Wis.

MAGNET CALCULATIONS

In introducing "Shading Coil Calculations for Single-Phase Magnets," by C. T. Evans (M '20) of the Cutler-Hammer company, Mr. Lassen emphasized the fact that the problem of design of a-c magnets has aroused considerable interest recently. He went on to say that the prime importance of such papers was that they filled the gap between textbook information and practical information developed by engineers in the industrial application of electrical engineering. Mr. Evans described an experimental procedure that has been found useful in the study of the calculations of power dissipated in the shading coil and helpful in the study of the instantaneous pull of the magnet. The experimental method described was one by means of which the validities of approximate calculations have been confirmed. This method also may be used effectively to study the nonlinear relationships between the magnetic fluxes and magnetomotive forces in single-phase shaded-pole magnets over a wide range of physical proportions. Much interest was shown by the audience in this paper, and discussions followed the presentation.

A-C CRANE HOIST SYSTEM

E. L. Schwarz-Kast (A '41) of the Armour Research Foundation, Illinois Institute of Technology, Chicago, Ill., pointed out in "A Thrustor Lowering Control System for A-C Crane Hoists" that the common interest in a-c lowering controls for crane hoists has increased steadily in recent years, because power plants now are generating a-c power almost universally and d-c conversion is costly and inconvenient. The general problem of lowering control was discussed, and common systems for a-c lowering were compared. Emphasis was placed upon the fact that there is a definite demand for an a-c lowering system which is simple, safe, has low-current consumption, and is inexpensive. Doctor Schwarz-Kast believes that the thrustor lowering system has these properties to a high degree, and he substantiated this by describing the thrustor lowering system in detail, covering the electric and mechanical equipment essential for operation, and by comparing the qualities of the thrust lowering brake with the mechanical load brake. To ascertain the consequences which a failure of the power supply might have on the thrustor lowering, a series of tests were performed showing in general that thrustor lowering is very satisfactory because of its reasonable speed range, simplicity, safety in operation, and low cost. One extremely important advantage of the thrustor lowering is that existing crane hoists can be equipped readily with this system without difficulties or great expense. G. W. Heumann (A '44) of General Electric Company, Schenectady, N. Y., in a discussion told how extensively and successfully this type crane hoist had been used in recent years, both in Europe and in the United States.

DYNAMIC BRAKING

"Dynamic Braking by Self-Excitation of Squirrel-Cage Motor," by A. Srinivasan, of the Illinois Institute of Technology, Chicago, Ill., and M. A. Thomas (M '39) of the New Mexico State College, State

College, N. Mex., was presented by Mr. Srinivasan. Many engineers have realized that this method could be used for dynamic braking, but little application of the principle has been made. A method for calculating the torque-speed characteristics and capacitor and resistor combinations with a minimum of experimental data about a motor, and a simple graphical scheme to determine the operating conditions at any speed were presented. Approximate value of braking torque can be calculated easily. The results of experimental tests conducted on a standard squirrel-cage motor were shown to agree reasonably well with calculated data.

"Dynamic Braking of a Single D-C Series Motor," by John D. Leitch (M' 42) of the Electric Controller and Manufacturing Company, Cleveland, Ohio, discussed various methods employed in obtaining dynamic braking with a single d-c series motor. Emphasis was placed upon the control of the dynamic braking contactors, where braking is required on power failure irrespective of direction o motor rotation. The use of polarized spring-closing contactors offers a simple and reliable solution when ruggedness of the equipment is important. Methods of obtaining graduated dynamic braking automatically also were considered. Because d-c series motors are used widely in steel mills, particularly on such auxiliaries as roller tables and on overhead traveling cranes, many drives require automatic stopping in the event of power failure or the tripping of an overload relay.

Service Problems on Distribution Circuits

G. B. Dodds (M '45) Duquesne Light Company, Pittsburgh, Pa., opened the distribution conference at the winter meeting on January 29 by circulating copies of a paper entitled "Necessity for Performance Records to Improve Further Continuity From Distribution Circuits," which he had presented before the transmission and distribution committee of the Edison Electric Institute in October 1946. Mr. Dodds also passed out copies of his paper, "Record of Faults on Distribution Circuits," for discussion at the conference session. After presentation of the two conference papers which dealt with means for reducing service outages and 4-kv fuse co-ordination, extensive discussion ensued, which was concerned largely with fault records and their use in reducing service outages. Also stressed in the discussion was the subject of public relations in the re-establishment of service after faults and the installation of aerial cable to reduce faults.

FAULT REDUCTION

"Measures for Reducing Outages," by H. P. Seeley (F '43) Detroit, Mich., was based on measures which have been used or are being tried by the Detroit Edison Company to reduce service outages on overhead lines. If expenditures to reduce service outages are to be most effective and economical, they must be based on as accurate a knowledge as possible of just what causes the outages, their length and frequency, and their location. Because maintenance crews are more interested in restoring service than in making records, it is difficult to get complete and accurate accounts of outages. On the Detroit system the average length of outages over five minutes in duration is about one hour, urban customers having such an outage about once in $4^1/_2$ years and rural customers about once a year. Weather conditions, which account for a great number of service outages, vary greatly from year to year, therefore a 10-year record seems necessary to take this into account. A number of the measures which have been used or tried for reducing outages on overhead lines include: avoidance of trees, ample conductor separation, bare wire where possible because of its good arc extinguishing characteristics, improved wire covering where needed, ring primaries, secondary banks, sectionalizing fuses, quick openings, short circuiters for use at time of line arc-overs, and aerial cables. The great cost advantage in overhead distribution lines points to their retention indefinitely for general use in most systems. By intelligent application of the measures listed it is possible to improve substantially the reliability of such overhead lines without greatly increasing their cost.

FUSE CO-ORDINATION

A paper, "4-Kv Fuse Co-ordination," by R. M. Havourd, Public Service Electric and Gas Company, Newark, N. J., stated that over the past 12 years tremendous advances have been made in the reliability of 4-kv fuses. In addition to the advances made in fuse design, much has been done in the development in new cutout designs and the improvement of old designs. This includes increasing their interrupting capacity in spite of the fact that their rating has not been raised. Use of this improved equipment has resulted in advantages to the customers which are: fewer customers interrupted at the time of a fault on the 4-kv circuit; speedier restoration of service; less likelihood of having "hot" wires on the ground; and the reduction in number of outages due to temporary faults if reclosing cutouts are used. Speedier restoration of service is possible, because no other fuse will have been blown or damaged, assuming proper co-ordination has been established beforehand. The difficulty which has been encountered in fuse co-ordination is the lack of electrical standardization between the fuses of various manufacturers. An attempt was made several years ago by a joint EEI–NEMA committee that did a great deal of work trying to arrive at a set of curves agreeable to everyone concerned which could become an industry standard. The war terminated the work of this committee, but within the past year work on the problem again has been resumed. The Public Service Company of New Jersey has carried out tests on tin and silver fuses which permitted direct comparison of the two types. In the five and one-half years, during which accurate performance records were kept, operation of the two similar test circuits indicated that the silver element fuse is somewhat less likely to blow on lightning surges. Although many fuse operations occurred throughout the test, not one of them was found to be improper.

Several discussions pointed out the increasing farm load as a major source of power system load. There are approximately 6,000,000 farms in the United States employing some 11,000,000 workers, and farming well may be considered an industry. If the power companies are to have their rural lines pay, they must obtain increased revenue from them by giving better service. Because a large number of farmers handle livestock, production losses occurring from service outages are not due only to direct causes but to indirect causes which may affect the production cycles over an entire year after a lengthy outage.

New Electronic Devices and Methods Described

Conferences are presented to bring new ideas and practices to the attention of the AIEE membership more rapidly than could be done through more formal channels. W. C. White (M '30) General Electric Company, Schenectady, N. Y., opened the conference on new electronic devices and methods.

"Electronic Dynamometer Control for Automotive Testing" was first described by E. F. Kubler (A '45) and H. W. Gayek, both of General Electric Company, Schenectady, N. Y. Electronic control of a d-c cradle dynamometer and its manual analogy were explained. This circuit is very similar to that proposed by O. W. Livingston (M '43) General Electric Company, Schenectady, N. Y., ("Electronic Constant Current Motor Systems") earlier in the week. The output of engines under simulated operating conditions may be more accurately determined by this dynamometer than by other calibrated loading devices. For tests of differentials and transmissions a constant-current loop with several machines is used. For each machine used as a motor to supply torque, another machine is supplying reverse torque and acting as a generator. With this system enormous forces may be exerted on the equipment with a net energy input equal to only the sum of the losses of the various motors and generators. Any type of loading, backing, coasting, and so forth may be obtained by control of the input torques of the various machines.

THE ELECTROFLASH

The necessity and methods of triggering light sources for photographic uses were discussed by H. J. McCarthy Sylvania Electric Products, Inc., Salem, Mass., in his paper, "The Electroflash." He demonstrated the manual operation of a portable electroflash, and explained that the flash lamp, which operates from a high-voltage capacitor, will deliver thousands of "flashes." The cathode and anode are at

opposite ends of a spiral glass tube whose length, diameter, and gas pressure are chosen to prevent firing of the tube until a triggering pulse is applied to it. Xenon at a pressure of 100 to 200 millimeters of mercury is used for the gas fill of the flash tube. The triggering electrode is a fine wire looped around each turn of the spiral which causes ionization of the entire tube of gas when an 8,000 to 10,000-volt pulse is applied to it.

Accurate co-ordination of the triggering circuit and the camera shutter is necessary to prevent multiple images or inadequate lighting, and a control tube was designed for this purpose, which has a cold cathode that may be operated by alternating current or batteries. For the high peak current output necessary in the control tube, the use of a helium gas fill was considered desirable. To insure reliability of firing, the area directly over the cathode is kept ionized by a steady current of approximately 40 microamperes flowing between a small wire anode and the cathode. The cathode to grid spacing was chosen to give minimum reliable trigger voltage, and low trigger grid current was obtained by exposing only a small portion of the grid surface to the cathode. Slides were shown to illustrate the physical characteristics of the tubes described.

TRAVELING-WAVE TUBE

The importance of the development of "The Beam Traveling-Wave Tube" was explained by one of its developers, J. R. Pierce of the Bell Telephone Laboratories, Inc., New York, N. Y. No other amplifier can approach the high band widths which will be necessary for multiplex television operation. This tube, which has a 200-megacycle band width, 23-decibel gain, 3,600-megacycle mean frequency, and 200-milliwatt output, works on the principle that a small force acting for a long time does as much work as a large force acting for a short time. The interaction of an electron beam and a wave traveling down a helix, each at approximately $^1/_{13}$ of the speed of light, causes the amplitude of the wave to increase exponentially as it travels down the tube.

DIELECTRIC HEATING

"A Novel Application of Dielectric Heating in the Furniture Industry" was presented by J. M. Cage (M '44) of Raytheon Manufacturing Company, Milwaukee, Wis. Present methods of glueing wooden panels for desk tops, tables, and other furniture uses animal glue applied to both of the strips and dried under pressure for 30 minutes. The glued joint is not strong enough to be sent directly to the planer, but must be stored for 6 to 24 hours. Appreciable heat may not be applied because of the low thermal conductivity of wood. With the use of synthetic resins, which at present are more easily available than animal glue, high-frequency dielectric heating is done in 30 seconds and no storage is necessary. High efficiency results from dielectric heating of the panels because the dielectric loss factor of glue is greater than that of wood and almost all the power supplied goes into heating the glue. Power is supplied from a high-frequency oscillator; inductance is inserted in series with the output to correct the power factor and prevent standing waves and resultant uneven heating of the work. Pneumatic pressure in the range of 250 pounds per square inch prevents warping of the boards as they are heated.

ELECTRONIC WELDING

William Parker of Radio Corporation of America, Camden, N. J., presented "High Frequency Welding." In the method described mutually induced eddy currents melt the metals to be welded. Upon fusion of the metals a uniform air-tight seam exists with no residual thermal stresses. Welding time is in the order of one or two seconds. Energy is supplied to the work coil, which is used to induce eddy currents in the work, from an impedance matching transformer, the primary of which is the inductance of the tank circuit of a high-frequency oscillator. Many particular welds were described and the work coils illustrated. The design of the work coils and jigs to hold the work make the process economic only on a mass-production basis. It is forseen that high-frequency inductance welding can have many time-, money-, and labor-saving applications in the electronic tube, the automotive, the aeronautical, and other industries.

Future Possibilities and Limitations of Light Production

The symposium on limitations of light production at the winter meeting on January 29 was under the guidance of S. G. Hibben (M '45) Westinghouse Electric Corporation, Bloomfield, N. J., and chairman of the AIEE committee on the production and application of light. Papers and discussion dealt only with the visible spectrum. Mr. Hibben presented an illustration that a 30 to 1 ratio exists between possible and present lights based on the theoretical 100 per cent mechanical efficiency of 620 lumens per watt for a single spectral line at 5,560 angstroms.

BRIGHTER LAMPS

In predicting the future of incandescent sources of illumination R. G. Slauer (A '41), Sylvania Electric Products, Inc., Salem, Mass., said in his paper, "Incandescent Illuminants," that the engineer but not the physicist could make some prediction about the coming ten years, because the engineer is concerned mainly with practical problems. The eye is the principal object for which light is produced, and other applications of artificial light are insignificant. The yellow-green portion of the spectrum permits greatest efficiency of the human eye, but psychological factors require that a balanced spectrum be used for light production, which limits maximum efficiency of illumination to 30 per cent, 100 per cent efficiency being based on a single spectral line. There is the possibility that developments within the next 100 years will broaden the reception of the eye, thereby permitting higher lighting efficiency. Present incandescent lamps are between two and three per cent efficient.

Illumination possible from molten tungsten amounts to 50 lumens per watt, but the metal cannot be used in this form. The light flux produced by a 60-watt lamp, the national average, operating at a temperature 1,000 degrees Kelvin lower than the temperature of molten tungsten, is 15 lumens per watt. By raising this temperature 100 degrees Kelvin, the efficiency may be increased 20 per cent, but cost of production of such a unit may be as much as six times as great as the present cost. Even a small increase in the absolute efficiency of the incandescent lamp, of which over one billion are purchased per year, will mean much to the power industry, because over 20 per cent of its output goes into burning out these lamps. The incandescent lamp is surpassed in some characteristics by the fluorescent and vapor dischage types, but each source will continue to be developed for its best use.

VAPOR LAMPS

"Vapor Lamp or Discharge Sources" was presented by Doctor H. C. Rentschler (M '40) Westinghouse Electric Corporation, Bloomfield, N. J. The major portion of output of the incandescent lamp is realized as heat, but radiation energy of the mercury vapor lamp is mainly ultraviolet, and only a very small amount infrared. In order to raise the lumen efficiency of a mercury discharge, the strong 2,537-angstrom resonance radiation must be suppressed, and the relative intensity of the other lines, especially the visible, must be increased.

Efficiency of mercury arc lamps increases from 30 lumens per watt at 10 microns pressure to 65 lumens per watt at a pressure in excess of 100 atmospheres, which is made possible by water cooling of the quartz envelope. A shift in radiation toward the longer wave lengths is produced as the vapor pressure is raised, and the color of the light is improved materially. Substitution of other metals, such as cadmium and zinc, for mercury produces strong spectral lines in the red, blue, and ultraviolet ranges, with no radiation in the orange and yellow-green bands. A similar arc discharge through sodium vapor in a lamp of very exacting design concentrates all the radiation in the yellow region of the spectrum with a possible efficiency of over 60 lumens per watt, but again with the serious lack of color range. Production of special refractories for containers to withstand greater operating temperatures are being developed. Doctor Rentschler demonstrated

the various types of lamps mentioned during presentation of his paper.

FLUORESCENT TUBES

Development in the United States on fluorescent sources started 12 years ago, and first extensive use was at the New York World's Fair which started in 1939, according to R. N. Thayer, General Electric Company, Cleveland, Ohio., in his paper, "Fluorescent Sources." In all important commercial designs of today, visible radiation is produced by a fluorescent material, the action being produced by passing an electric current through a mixture of mercury at about ten microns pressure. The fluorescent lamp is basically an electric discharge lamp, and it possesses, in common with the vapor lamp, the need for a cathode and an anode, and for a ballast and circuit to initiate and stabilize the arc. Variations in color are produced by combinations of the various fluorescent phosphors. Present phosphors are transforming energy at about 80–90 per cent efficiency within the quantum limit (a wave length transformation of energy can occur only at a maximum limiting efficiency represented by the ratio of the wave lengths involved). Because the ratio of wave lengths of exciting ultraviolet to phosphor radiation is about 50 per cent, an energy loss of approximately 50 per cent is involved.

Fluorescent lamp design and performance for maximum light output definitely are tied to the maintenance of a lamp-wall temperature in the vicinity of 100–105 degrees Fahrenheit, which is required to establish optimum mercury vapor pressure to yield maximum efficiency. Low ambient temperatures make lamp starting difficult. Metallic vapors other than mercury require elevated temperatures to furnish the desired vapor pressure; consequently, as with the sodium lamp, they require considerable wattage to maintain these temperatures and so are not feasible for present lamps.

Another factor involved in the design of fluorescent tubes is the brightness built up by internal reflection. Therefore, relatively short lamps suffer in efficiency, because a longer proportion of their total length is required to build up normal brightness. In the conventional preheat-start circuit with starters, the inductive kick produced when starter contacts open is usually sufficient to break down the arc gap, regardless of ballast open circuit voltage, which is determined by the minimum value required to sustain the arc under conditions of minimum line voltage and maximum lamp voltage, and to hold the starter out of action, once the lamp is started. An unusual factor in the starting qualities of fluorescent lamps is humidity. It has been found that during periods of high humidity an extremely high starting voltage is required for the majority of fluorescent tubes. This difficulty has been eliminated by introduction of a stripe of conducting material to introduce added capacitance in the starting circuit of the lamp. Lamp current wave shape affects lamp performance and manufacturers commonly set a peak-rms ratio of 1.7 as a permissible maximum to obtain rated lamp performance.

Future possibility in lamp size and wattage appear limited compared with filament lamps, because of the heat generated. Lamps must be long to be efficient, and average length is likely to increase. A circular design has been developed to obtain increased length in smaller space.

Hydroelectric Systems Subject of Wednesday Session

At a session January 29 sponsored by the AIEE committee on power generation, four papers were presented on different aspects of hydroelectric stations before an audience of 160. The first paper, a conference paper on "Characteristics of Hydraulic Turbines That Effect Operating Efficiency," was presented by W. J. Rheingans, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., substituting for J. F. Roberts of the same company. Mr. Rheingans reviewed operating and design features on hydroelectric stations that affected over-all plant performance.

He cited proper load division between turbines as the first consideration for maintaining plant efficiency. Systems with both run-of-river and storage plants must be scheduled to waste the minimum of water. When steam stations are also a part of the system, this becomes doubly important in order to effect minimum fuel consumption. Proper operation of spinning-reserve units will save appreciable amounts of water; by motoring the reserve units with gate closed and tail water depressed instead of operating them with water flow at zero load, considerable water can be saved for later use.

Air venting of the turbine runner markedly increases part-load unit efficiency. Tail water depressing systems using compressed air should be provided wherever units are to be motored on reserve. This not only increases over-all economy but will reduce turbine maintenance by allowing the runner to revolve in air instead of churning water. System governing should be performed by as few units as possible because steady load on a unit will help to realize optimum efficiency. He advised against the installation of small water-wheel driven auxiliaries, better plant efficiency can be achieved by electrically-driven auxiliaries. Small house generators are equally undesirable. When hydroelectric units are shut down for any length of time, the head gates or penstock valves should be closed to eliminate any leakage through wicket gates and needle valves. Finally, Mr. Rheingans advised the collection of complete performance data on a unit in order to give the operator complete information on which to base his operating schedules.

MODERN BEARINGS

In the second presentation of the session C. M. Laffoon (F '45) and R. A. Baudry, both of the Westinghouse Electric Corporation, East Pittsburgh, Pa., discussed "Modern Bearing Practice for Vertical Water Wheel Generators." They said that the need for units of greater capacity has required a parallel increase in dimensions of guide and thrust bearings which, in turn, dictated improvement in design and manufacturing procedures. This involved provision of special machine tools and an air-conditioned room supplied with filtered air maintained at constant temperature to obtain a satisfactory finish on thrust bearings.

Improved design stresses the need of tight-fitted thrust collars to achieve satisfactory performance and minimum maintenance. The most critical period for thrust bearings occurs during starting. The recommended procedure was the use of oil-operated jacks to lift the rotor and subsequent introduction of oil into the bearing to establish the lubricating film. Tests have shown that the oil film during starting is not established fully until after 30 rpm is reached, while on shutdown the film persists until a speed of 1 rpm is reached. A machine should be started only with cold lubricating oil, otherwise, when the unit is up to speed, the increasing temperature may prevent establishment of the proper lubricating film.

The importance of the rigid, tight-fitted thrust collar was corroborated in a discussion by R. O. Standing, Hydro-Electric Power Commission of Ontario, Canada, who stated that a considerable portion of their troubles was attributed to "loose fits" between collar and runner plate. This causes pitting of the collar bore and shaft and also of the collar lower surface and the runner plate upper surface. Most troubles have been near-failures that are detected by inspection and occur after about ten years of bearing service. This pitting also is attributed to either poor assembly or poor alignment, or both. No data are available as to whether these errors are the result of defective assembly or settling of the machine foundations. They jack their rotors to establish oil film after lengthy shutdowns.

T. W. Gordon, General Electric Company, said that their successful manufacture of large thrust bearings was attributed to the use of a precision boring mill with suitable tools and the provision of suitable protection of this equipment from the dirt found in ordinary large shops. Cleanliness is essential and constant temperature was found to be a necessity. For establishing bearing oil films before rotation, the General Electric Company favors the use of high-pressure oil feed direct to the bearing. In a test on an experimental bearing, oil was supplied at 1,000 pounds per square inch; as the film was formed the rotor rose about 0.006 inch, pump pressure dropped to 350 pounds per square inch, and starting friction was reduced to a small amount as shown by the noiseless start of the rotor.

Use of high-pressure oil for starting also was favored by E. I. Pollard (M '45) of the Elliott Company, Ridgway, Pa. He felt that there was danger of pulling the bearing babbit loose by jacking up the

rotor. High-pressure oil was advocated as simplifying turbine starting procedure and as providing a convenient means of checking the thrust load on the various shoes.

The first Kingsbury thrust bearing to be installed on a vertical hydroelectric unit is still in service on one of the Holtwood station units after 35 year, according to B. Van Ness, Jr. (M '35), Safe Harbor Water Power Corporation, Baltimore, Md. He stated that jacking of rotors is not possible with all bearing designs. In units where the runner plate is fastened to the thrust, block shoes have been known to adhere to and to rise with the runner plate during jacking.

AUTOMATIC STATION CONTROL

M. J. Brown (M '44) and W. A. Derr (A '43) both of the Westinghouse Electric Corporation, East Pittsburgh, Pa., in their paper on "Automatic Control of Hydroelectric Generating Stations" revealed that automatic stations have been in use for 60 years but many improvements have been developed in the last ten years. These stations are controlled through one of three methods: by a single pair of telephone wires, a transmission line carrier channel, or by space radio channel. An unlimited number of operations can be performed by remote control through any of these means. The largest unattended station has 30,000-kva capacity.

Machines of any size can be synchronized by automatic speed matching and synchronizing equipment and brought on the line at correct voltage and phase angle. Smaller machines up to 5,000-kva capacity can be placed on the line by self-synchronizing in which the circuit breaker closes at less than synchronous speed and the machine synchronizes after the field switch closes. Telemetering equipment is a necessity for remote control and uses the same communication channel as the supervising instruments. Manual controls usually supplement the automatic equipment in the station.

TESTING GOVERNOR PERFORMANCE

A new instrument for analyzing steam turbine or hydroturbine performance was described by J. E. Allen (M '39) Pennsylvania Water and Power Company, Baltimore, Md., and W. B. Hess, Safe Harbor Water Power Company, Baltimore, in a paper on "Testing Governor Performance on Electric Power Systems With Improved Instruments." The instrument is a new direct-writing frequency recorder having fast pen speed, large pen-arm force, and high sensitivity. It makes two records simultaneously, one on a strip chart showing variation of frequency and operating-piston motion or load with time, and another card giving a direct plot of piston motion or load versus frequency. These cards show directly, without necessity for intermediate calculation, such governor characteristics as sensitivity, dead band, incremental speed droop, and incremental speed regulation. Various tests were shown that demonstrated the influence of friction and adjustments on over-all governor performance throughout its operating range.

C. L. Avery, Woodward Governor Company, in commenting on the negligible meter drift during the five to ten minutes required to run a test, wondered what it might be over an extended period. The authors answered that a 2-hour observation period showed no apparent drift. Mr. Avery strongly recommended frequent use of the instrument to detect need of governor maintenance.

G. J. Vencill (M '44) Union Electric Company of Missouri, St. Louis, pointed out that for compensated governors the card diagram shape will depend considerably on the speed with which the frequency changed and the characteristics of the frequency pattern. These would have to be considered in any analysis of the governor performance.

C. K. Duff (M'41) Hydro-Electric Power Commission of Ontario, Toronto, Canada, suggested an added feature for the instrument to indicate the speed of governor response from impulses originating in automatically operated or manually operated equipment.

F. Oppenheimer (A '09) Pennsylvania Water and Power Company, suggested three methods of testing governors over their full frequency range with this recorder. In addition to the various governor conditions exhibited by the authors, Mr. Oppenheimer showed an instrument record of a governor after overhaul that clearly showed high sensitivity, narrow speed droop, and small time lag. (*Report submitted by B. G. A. Skrotzki (M '45) secretary of the AIEE committee on power generation.*)

Improvements in Rural Telephone Facilities

F. A. Cowan (M '29) American Telephone and Telegraph Company, New York, N. Y. called the attention of the audience at the session on rural telephone facilities on January 29 to the widespread interest in rural telephone service. Joint use of poles by power and telephone lines, and carrier telephony makes possible extended use of existing parts of systems, and the possibility of more economic planning for future installations. Radiotelephony is still in the experimental stage.

CARRIER TELEPHONE SERVICE

The progress since 1936 in development of means of providing "A Carrier Telephone System for Rural Service" was summarized by J. M. Barstow (A '35) of Bell Telephone Laboratories, Inc., New York, N. Y. Isolating chokes are provided on all unused portions of the power system to prevent spillover of the communication energy, and all lines must be terminated in characteristic impedance because mismatch at high frequencies cause standing waves which are not permissible. Transmission chokes are used at each tap point where the tap impedance makes it necessary, and coupling capacitors are used on other branches. The systems include conversion elements, generating elements, modulators, demodulators, couplers, and switching equipment, and equipment is installed so that a telephone set and a subscriber carrier terminal are in the customer's house. This terminal consists of a carrier-frequency oscillator, modulator, transmitting amplifier, receiving amplifier, demodulator, filters, relays, power supply, and associated equipment which is housed in a small box usually attached to the baseboard near the telephone set. From the terminal a carrier drop wire is carried to the coupling unit that usually is mounted on the nearest high-voltage power pole. The subscriber coupling unit includes selective filters, relay, carrier-frequency transformer, and associated safety switch and protectors. A high-voltage coupling capacitor also is mounted on the pole and a fuse interposed between the capacitor and the power phase wire. Similar equipment is installed in the reverse order at the common terminal point where connection is made to a voice-frequency pair which leads to the central office. Also the common terminal contains hybrid coils for combining the incoming and outgoing signals on the same voice frequency line, power supply, and other associated apparatus. In closure it was stated that this telephone system will aid in the accomplishment of ideal service, that by which any one in the United States may talk to any one else quickly, clearly, and at reasonable cost.

Carrier telephony was further discussed by G. R. Messmer in his presentation of "Application of Rural Carrier Telephone System," by E. H. B. Bartelink (A '46) of General Telephone Corporation, New York, L. E. Cook (F '45) of Ebasco Services, Inc., New York, F. A. Cowan, and himself. The design data and performance characteristics of the equipment described by Mr. Barstow were given. Eight systems of this type are in operation, all having been completed since October 1946. These systems range in trunk-line length from 8 to 19 miles and all are operated on a single-channel scheme, and have 4 to 8 subscribers each. A multi-channel system is planned. The necessity for shunting the solenoid coils of circuit breakers by a capacitor or a 50-ohm resistor to avoid excessive loss at carrier frequencies was mentioned in the discussion. One of the discussers mentioned that although the system described was designed for distances of over a half mile between customers, the American Gas and Electric Company, New York, N. Y., is investigating the use of such a system on its lines, all of which are in more densely populated areas.

JOINT USE OF POLES

"Joint Use of Pole Lines for Rural Power and Telephone Services" by J. W. Campbell (M '39) of American Telephone and Telegraph Company, New York, N. Y., L. W. Hill (M '31) of Carolina Telephone and Telegraph Company, Tarboro, N. C., Lee M. Moore (F '45) of Rural Electrification Administration, Washington, D. C., and H. J. Scholz (F '46) of Commonwealth and Southern Corporation,

Birmingham, Ala., presented by Mr. Scholz, describes the modification of an existing 75.6-mile power line in Alabama for joint use. Economic studies still in progress indicate that where new extensions are to be made, joint use will effect economy for both the power and telephone systems. Modification of already existing lines introduces an additional element of cost, but it appears that there will be an over-all economic advantage in favor of joint use as compared to use of separate pole lines.

OPEN-WIRE CONSTRUCTION

"Open-Wire Construction for Rural Telephone Lines," a conference paper by C. G. Sinclair, Jr., American Telephone and Telegraph Company, New York, N. Y., D. M. Barnes (A '35) of Associated Telephone Company, Ltd., Santa Monica, Calif., and F. V. Haskell (A '27) of Bell Telephone Laboratories, Inc., New York, N. Y., was presented by Mr. Sinclair who stated that open-wire construction has been and will continue to be the fundamental method for transmitting telephone signals in rural areas. Important construction features include: new conductors which make possible the use of long spans and small poles; "pin socket poles," which eliminate crossarms, are stronger, and less work to install; power-operated posthole diggers which have been a great aid in rural installations; use of "spiral tie" which prevents excessive wear of the conductors at the insulators and acts as a damper to relieve fatigue stresses; and tandem transposition brackets which make possible simple transposition schemes greatly simplifying installation. Howard Enos (M '27) of American Gas and Electric Service Corporation, New York, N. Y., challenged the economic necessity for the separation specified between telephone pairs and power cable. He proposed that temperature range and ice loading in a given region be investigated and used to determine the separation necessary, and gave typical figures to support his proposal. Mr. Campbell replied that there is an opportunity for further investigation. The ruling span in the Alabama survey was 350 feet. There are approximately 6,000,000 poles in joint use in the Bell System, which has an excellent safety record, and which will change its specifications only if experience show that it has been too conservative.

COLORADO EXPERIMENT

The "Rural Radio Telephone Experiment at Cheyenne Wells, Colorado," written by J. H. Moore of American Telephone and Telegraph Company, New York, N. Y., P. K. Seyler of The Mountain States Telephone and Telegraph Company, Denver, Colo., and S. B. Wright (M '31) of Bell Telephone Laboratories, Inc., New York, N. Y., was summarized by Mr. Wright. Radio telephony may be of particular use in sparsely settled areas such as the one tested. Eight ranches were served; four were connected directly by radio and the remaining four were served by a 5-mile wire system extending from the most remote radio-equipped location. The results of this experiment were encouraging, although there is not sufficient data to make predictions. It is definitely recommended that for further experimentation the carrier frequency be moved out of the 44 to 50 megacycle band. This system has operated successfully at a rate of three or four calls per station per day. It was given a severe weather test in a snow storm in November 1946, when the antennas were bent from the ice which encased them but were not permanently deformed. Once during this period the system was used to obtain medical advice for use at an otherwise completely isolated ranch. It was found that the most maintenance was necessary in replacement of the receiver vibrator power supply unit. This is probably because this unit operates continuously. It is hoped that the results of this experiment will make possible the development of a standard rural radiotelephone system.

Subcommittee Reports at Industrial Voltage Conference

At the conference on industrial voltages held Wednesday afternoon January 29, C. C. Whipple (M '26) of Polytechnic Institute of Brooklyn, Brooklyn, N. Y., presided. D. L. Beeman (M '43) of General Electric Company, Schenectady, N. Y. presented an interim "Report of the Subcommittee on Industrial Voltage Requirements" compiled by the subcommittee of the AIEE committee on industrial power applications. This presentation was divided into two parts; a brief historical review of the work of the subcommittee and, a discussion of the major points of the report.

Interim reports issued by the Edison Electric Institute and the National Electrical Manufacturers Association on the subject of preferred voltage ratings for a-c systems and equipment, and the background gained in preparing this report, indicated that more studies should be made from the standpoint of the user's requirements. Consequently, the AIEE subcommittee was formed, and its work began with the January 1945 winter meeting. The basic objectives of the subcommittee are: (1) to show the importance of proper utilization voltage for satisfactory operation of industrial electric apparatus, (2) to recommend voltage spreads at the terminals of utilization devices under normal operating conditions, and (3) to recommend preferred voltage ratings and taps for industrial power transformers.

The scope of the work of the committee applies only to those industrial plants receiving power at primary voltage; that is, at 2,000 volts or higher, or to those which generate their own power at 2,200 volts or higher. The work is not intended as an AIEE Standard, nor is it intended that any recommendations be regarded as restrictive. Investigations were based on utilization devices with ratings as they exist today to determine voltage spreads for satisfactory operation of this equipment.

Certain terms used in the report were defined explicitly. These included nominal voltage, rated voltage, voltage spread, voltage zone (primary voltage zones are the only ones referred to in the report), transformer voltage rating, transformer taps, and voltage drop. Slides were shown and actual examples cited of the effects of voltage drop and primary spread on utilization equipment of varied types.

The review of the operating performance of varied operating equipment led to the committee's recommended limits of voltage at the terminals of utilization devices and those at the terminals of motors. These bear agreement with the EEI–NEMA report favorable zone. The ratings are based on nominal system voltages of 208Y/120, 230 (240), 460 (480), and 575 (600). It was believed that the inclusion of two limits would have been contradictory and misleading, as no attempt was made to consider abnormal conditions in this report.

No agreement has been reached concerning standard transformer ratings for industrial circuits. It is believed by certain members of the committee that lower secondary voltage rating should be employed; that nominal system voltages should be lower than 240, 480, and 600; and that the secondary voltage ratings of the transformer and nominal system voltages should be the same, to reduce the various voltage designations for any one class of system. These points are to be discussed with EEI–NEMA groups.

A discussion by R. N. Slinger (A '34) of General Electric Company, St. Louis, Mo., requested clarification of the definition of voltage spreads, and it was brought out that dips were not included. L. A. Umansky (M '27) of General Electric Company, Schenectady, N. Y., made the recommendation that the settlement of problems and agreements be reached by the time of the summer meeting, to which there was enthusiastic agreement. K. Pinder (M '37) of E. I. du Pont de Nemours and Company, Wilmington, Del., described economic studies which found it to be cheaper to use 208/120-volt 3-phase systems for lighting, rather than 115–230-volt single-phase systems. John Grotzinger (M '44) of Goodyear Tire and Rubber Company, Akron, Ohio, has arrived at the same conclusion. L. C. Peterman (M '44) of Ford, Bacon, and Davis, Inc., New York, N. Y., praised the committee because it finally had broken from the concept of having nominal system power voltages which are a multiple of the lighting voltages. For example, a lighting voltage of 120 and power voltage of 460, instead of 480, is recommended in the report. Mr. Peterman said further that a more economical system resulted when his company designed a system using single-phase transformers at lighting panelboards. In response to a question of L. A. King (A '41) RCA Victor Division, Radio Corporation of America, Camden, N. J., it was revealed that the trend of circuit voltages in control circuits was outside the scope of the report.

The paper, "Voltage Regulation for Industrial Systems," of which Mr. Beeman was coauthor, was presented in three parts by R. C. R. Schulze, of American Gas and Electric Service Corporation, New York,

N. Y.; H. G. Barnett (M '41) of Westinghouse Electric Corporation, East Pittsburgh, Pa.; and W. H. Dickinson (M '43) of Standard Oil Development Company, Elizabeth, N. J. The purpose of the paper, as stated by Mr. Schulze, was to outline certain methods which might be used to achieve voltage control. This adjustment may be accomplished by induction regulators, step-type regulators, tap changing under load on transformers, static capacitors, adjustment of field on synchronous motors, or electronic regulators. Details describing these methods and examples of where they may be used were ennumerated. Mr. Schulze pointed out that these electronic devices usually are entirely automatic and instantaneous in their operation, and consequently may be particularly adaptable in certain cases.

Mr. Barnett spoke of the effect of voltage control on plant distribution system design. He described the relationship between supply voltage variation and possible voltage drops in a plant distribution system and outlined some improvements in supply voltage variation which permit greater regulation (drop) in that system. Voltage regulation may be combined with fixed capacitors to prevent overvoltages at light load and give a higher voltage level along with smaller voltage spread throughout the plant system. Because of these factors, voltage regulation may save money in the over-all plant distribution system.

In conclusion Mr. Dickinson related the general cost of operating with these regulating devices, saying that they are "approximate estimated costs."

Diverse Subjects Presented at Session on Electric Machinery

A technical session on electric machinery attended by approximately 100 engineers met on January 28 at the winter meeting, presided over by F. S. Brown (M '27) of the Duquesne Light Company, Pittsburgh, Pa.

Paul Narbutovskih (M '43) of Westinghouse Electric Corporation, Sharon, Pa., presented his paper, "Simplified Graphical Method of Computing Thermal Transients," describing a method of estimating the available overload capacities of the individual power transformer equipments. The author made known the fact that the method described in his paper is not a venture in a new direction, because a number of simplified methods for computing thermal transients have been offered in the past, both graphical and semigraphical. However, the author felt that these methods are based on more or less complex charts with need for simplification, and that the method described in his paper possesses a degree of simplicity and generality, worthy of presentation.

IMPREGNATED INSULATION

The object of "The Dielectric Properties of Cellulose Insulation Impregnated with Semiconductor Liquids," by F. M. Clark (A '24) of the General Electric Company, Pittsfield, Mass., was to illustrate the abnormalities which are met when cellulose insulation is impregnated with high-loss liquids, and to introduce the development of a new type of capacitor which is characterized by a high electrical capacitance per unit of physical volume. Such a capacitor offers promise in applications at voltages higher than those at which electrolytic capacitors can be used continuously with safety and lower than those at which the usual paper-spaced oil or askarel-treated capacitor can be used with economy. The Permalytic capacitor operates with a power factor of about three per cent. This type capacitor offers interesting possibilities for applications where a small, dependable, low cost, low-voltage capacitor is required.

EFFECT OF WAVE FORM

"A Study of the Relative Severity of Steep-Front Waves and Chopped Waves on Transformers," by F. J. Vogel (M '41) of the Illinois Institute of Technology, Chicago, Ill., was the final paper presented on this program. In the effort to remove empirical practices and place design work on a sounder basis, it was found necessary to determine some means of evaluating the dielectric strength of transformer line coil assemblies as well as to find the actual voltage stresses which existed. In this paper the author showed why the actual strength between coils cannot be estimated easily and why it is not the same with voltage rise or fall. It is greater when the voltage collapses on chopped-wave impulse test than for steep-front waves.

There was considerable discussion about the paper on graphical computation, some discussers preferring the direct methods of analysis and calculation to graphical methods, while others seemed to feel that a graphical method simplified the problem.

Increasing Electrification of the Textile Industry Described

Approximately 100 engineers and manufacturers interested in the electrification of the textile industry attended the technical session on applications in the textile industry, January 30, at the winter meeting. This was the first time in the history of the AIEE that a session was devoted to the problems of electric equipment in the textile industry. The meeting was presided over by Philip Bliss (M '45) of New Britain, Conn., who is with the Raymond Engineering Laboratories, Middletown, Conn.

POWER DISTRIBUTION

J. D. McConnell (A '31) Proximity Manufacturing Company, Greensboro, N. C., in "Power Distribution in Textile Plants," traced the growth of the textile industry from its early stages, when it was imperative that it be located on water power sites to be within mechanical transmission distance of the power source, up to the present day when the main operations in a textile plant are carried on electrically. The first major application of electricity in textile plants was for lighting, and since that time the textile industry has been quick to adopt the latest lighting developments. Today this industry is one of the important users of fluorescent lighting. Mr. McConnell also covered the requirements for textile machinery, including reliability, safety from fire, and ease of installation and maintenance. The matter of a constant power supply is dealt with differently in mills that generate all or a part of their power and those that buy from a public utility.

A hazard which has to be taken into account in the usage of electric equipment in a textile plant is that from fire. Motors must be designed with no openings in the motor where lint can collect, become jammed between moving surfaces, and through rubbing, be heated to the kindling point, or become exposed to sparks from brush arrangements. Also, the possibility of electric apparatus being doused by water from sprinkler heads or other fire protective equipment must be considered. This has led to the early adoption of completely enclosed equipment in cotton mills.

One problem which is especially troublesome in certain parts of the cotton mill is vibration, especially in weave rooms. In severe cases wiring in conduits has vibrated enough to cause abrasion on the conductor jacket.

The trend in power usage in the cotton textile mills is upward, both from the standpoint of kilowatt per square foot of mill area and per employee. This trend will increase in rate of change as various mechanical limitations to higher speed in the textile machinery are removed by future development. The cotton industry is not static in its pressure for development, and other branches of the textile industry are just as aware that there is a constant change in the competitive situation and customer demand. It is well to note that this industry, which for many years had few technical men, is now a field that recognizes the importance of the engineering and research approach to its problems. The industry is conversant with such things as infrared and radio frequency heating, control of static electricity by high-voltage and radioactive ionization, stroboscopic observation and photography, and other new developments in the electrical field.

ELECTRIC TWISTER

"Electric Equipment for Two-for-One Twister," by E. C. Gwaltney and H. J. Burnham, both of Saco-Lowell Shops, Biddeford, Maine, presented problems in the synthetic fabrics industry and offered

as one of the solutions an all-electric machine. The Saco-Lowell two-for-one twister is one of the most complete approaches to the all-electric machine ever attempted in the textile industry. This paper covered the problems encountered in electrifying the machine, the steps being taken to overcome them, and the simplification of the electric components of the machine. Textile fibers are either natural or synthetic, and either type must be twisted into yarn before it can be woven into fabrics. The amount of twist is measured in turns per inch and is the ratio of rotation of the spindle to linear speed of the yarn.

Although it is planned ultimately to apply the two-for-one principle to all forms of twisting, its use at present is confined to the twisting of fine dernier rayon and nylon. The practical operation for the two-for-one twister requires that the spindle rotate at approximately 12,000 rpm. The first attempt to build the machine were along mechanical lines, but belt slippage, maintenance, yarn cleanliness, and over-all flexibility presented difficult problems. Complete electrification provided a satisfactory solution to these problems. The physical and electrical aspects of this equipment were discussed. Studies have shown that power cost per pound of yarn produced on two-for-one twisters is in the order of one third of that on conventional machines. It is expected that two-for-one twisters eventually will replace all forms of twisting except on those yarns requiring an extremely low twist; and it is hoped that electrification of spindles on the present machine will point the way to future electrification in the textile industry.

Adjustable-voltage d-c splashproof motors drives on a continuous dyeing range in a large Southern bleachery with load-indicating ammeters and tension-adjusting rheostats mounted above them

ELECTRIC DRIVES

In "Electric Drives for Textile Finishing Ranges," R. B. Moore (A '45) General Electric Company, Schenectady, N. Y., and H. C. Uhl (M '40) General Electric Company, Atlanta, Ga., gave general information on textile ranges, including the basic requirements of range drives, basic consideration in selecting drive equipment, comparison of electric and mechanical drives, description of various types of electric drives and co-ordination control, and recommendation for selecting proper equipment for specific conditions. In his presentation Mr. Moore stressed the fact that the right kind of equipment for the application must be considered very carefully by the engineer. Electric drives are used now on textile ranges almost to the complete exclusion of mechanical drives. Various types of d-c and a-c drives were discussed, and one of the most interesting aspects of the paper was a guide for engineers in making proper selection of drives to meet specific requirements. This should be helpful to all those concerned with the application of such equipment.

SOUTHERN ELECTRIFICATION

S. A. Bobe (M '44) of Westinghouse Electric Corporation, Atlanta, Ga., in "Electrification of the Cotton Industry in the South," traced the growth of the use of electric apparatus in the cotton industry and pointed out that the major share of this rise which has taken place in the past 20 or 25 years, still is not completed. The actual processing of cotton was traced from the time it entered the mill until it was woven on the loom. Each particular phase of this complete process was discussed individually with stress on the type of electric equipment used. Mill drives, cards, drawing, weaving, spinning, and so forth, each requires a specific type of electric apparatus. Motors on the warpers are equipped with brakes for quick stopping. Most important motors are those which operate slashing machines because faulty slashing is costly and results in loom stoppage and lower grade cloth. Mr. Bobe clearly showed the importance of the cotton industry as an electric power consumer vitally interested in new developments such as new motor installations, unit substations, dielectric heating, electrostatic air cleaning, air conditioning, and electronic drives.

All-Day Conference Held on Aircraft Safety

Factors affecting the safe operation of electric apparatus in aircraft were discussed informally in an all-day conference on January 30 by representatives of aircraft accessory manufacturers, major aircraft manufacturers, air-line operators, and representatives of the Civil Aeronautics Authority and the Armed Forces. Cochairman at the conference were F. M. Roberts (M '42) General Electric Company, Schenectady, N. Y., and J. D. Miner (M '42) Westinghouse Electric Corporation, Lima, Ohio. Attendance was estimated at 250.

The main theme of the conference was the highlighting of the increasing dependence of modern aircraft on its electric equipment and its evaluation in safety considerations. The subject was divided into five parts: safety, history, and requirements, including present-day standards and needs; types of electrical failures such as loss of power source, loss of power at important load center, fire and smoke, and hydraulic considerations; protection in the electric system; application considerations such as environment and loading; and the safety program. Recommended practices for the prevention of apparatus and system failures and the associated protective devices were covered, as well as experimental work now being carried on for future improvements in electric and hydraulic systems.

A. A. Gray, Civil Aeronautics Authority, pointed out that the CAA was no longer "much concerned" with major items of electric apparatus for airplanes, because failures there occurred so seldom and were protected so well, but advised manufacturers to concentrate on improving the "two bit items" such as switches and indicator lamps.

Earl Barlow, Glenn Martin Company, stressed the need for electric systems which would require a minimum of servicing, because "ground crews do not always look at the things you want them to," and J. B. Tracey, Pan American Airways, recommended that the CAA establish an "aircraft electrician's rating" to ensure that ground crews contain men fully familiar with the complex equipment now being in-

stalled aboard airplanes for greater safety.

Two papers on the subject of application considerations were presented: "Parallel Operation of Aircraft Alternators Using Electronic Frequency Changers," O. E. Bowlus (M '46), P. T. Nims (A '40), both of the Chrysler Corporation, Detroit, Mich.; and "An Integrated Control System for Aircraft D-C Generators," A. T. McClinton (A '42) Naval Research Laboratory, Washington, D. C. The former paper was a report of initial work on an electronic method for operating several main aircraft engine driven alternators in parallel to supply the electric loads of an airplane. This would make unnecessary any mechanical constant speed drive for each generator. The paper by Mr. McClinton described an electric system for d-c generators used on aircraft that allows physical integration of all control elements normally associated with the control of the generator. The prosposed system differs from the present system used by the Army and Navy in that integration has been accomplished in addition to offering completely automatic control of the generating system without a sacrifice in system performance.

Many Problems Discussed at Session on Basic Sciences

J. D. Tebo (M '36) of Bell Telephone Laboratories, Inc., New York, N. Y., presided at the basic sciences session on January 30 at the winter meeting. The first paper was "Eddy Currents in Disks: Driving and Damping Forces and Torques," presented by A. D. Moore (F '43) of University of Michigan, Ann Arbor. The paper was limited to the case in which the eddy currents in the disks are too small to affect the fluxes. A uniform flux may be represented by a slim pencil of flux and the eddy currents which result from this flux may be more easily handled if the flux is considered to exist in an infinite disk and an equal and opposite image flux also is considered. These two conceptions aid materially in calculating the torques between two a-c fluxes. The law of reciprocity may also be used. By this method the variation of torques between two fluxes as they are moved simultaneously along radiuses toward the center of the disk may be calculated. Surprisingly enough this torque does not reach a maximum until the fluxes touch each other. A simple chart may be derived to make repeated calculations of torques unnecessary. Resulting torques may be predicted to within 12 per cent by mapping the fluxes existing in a standard watt-hour meter and using the method described. Through assumption of a constant flux in the light of flux bands and constantly increasing or decreasing flux points, and integration of the reaction between two flux areas damping torques may be computed. A chart is also presented for this. Watt-hour meter damping torque was predicted to within five per cent. Unevenly distributed fluxes may be represented by plotting contour lines and considering the flux between each line as constant. The calculation and resulting table of translational damping were given.

B. E. Lenehan (A '24) of Westinghouse Electric Corporation, Newark, N. J., pointed out that the accuracy of this method is limited by its two dimensional concepts. He thinks the use of the trial and error analogy to solve field problems takes no more time than this method. He suggested that constant flux density be considered rather than constant flux in the problem of moving two fluxes radially toward the center. In this case a maximum flux occurs at approximately seven tenths of the radius of the disk. J. A. M. Lyons (A '38) Alexandria, Va., in a discussion ready by J. F. Calvert (F '45) of Northwestern Technological Institute, Evanston, Ill., agreed with the mathematics and physics of the paper, and the aid of the chart. He introduced the concept of a perfectly conducting edge as a substitute for the image theory and noted that it is not a true representation. He raised the question of the use of the theory on irregular shapes.

HYSTERESIS LOOP TRACER

Test and equipment used for research with magnetic recording material was described in the paper, "A 60-Cycle Hysteresis-Loop Tracer for Small Samples of Low-Permeability Material," by D. E. Wiegand (A '42) and W. W. Hansen, both of Illinois School of Technology, Chicago. The tester consists of a large exciting coil with a pickup coil at its center, an amplifier and integrating circuit, and a cathode-ray oscilloscope. The developmental problems were described and their solution indicated. Convenience of operation makes the collection of complete data possible on magnetic wire and tape, and this instrument might well be adapted to other magnetic media. The use of the plate resistance of a pentode to replace the resistance of the integrating circuit of the machine was suggested in the discussion.

NETWORK PERFORMANCE

"Machine Computation of Power Network Performance" was presented by L. A. Dunstan (A '40) of Federal Power Commission, Washington, D. C. The result of machine computation may be more accurate than those of the network analyzer if the convergence of the results of successive approximation, which are used for further more nearly accurate approximation, is utilized. The statement of a problem for general system analysis and its method of adaptation was given. F. S. Rothe (A '36), in a discussion read by F. J. Maginnis (A '43) both of general Electric Company, Schenectady, N. Y., stated that certain system values that were assumed to be known, such as the generator reactive power and the voltage ratios of transformers, are not generally known, while certain other values, such as bus voltages, usually are known. W. C. Johnson (M '42) of Princeton University, N. J., hailed the paper as presenting a fresh point of view and a complement method rather than a competitor of the network analyzer. T. J. Higgins (A '40) of Illinois Institute of Technology, Chicago, reviewed other similar computers, their use, and applicable problems.

EFFECTIVE RESISTANCE

Herbert B. Dwight (F '26) of Massachusetts Institute of Technology, Cambridge, has collected and supplemented existing data in his paper on the "Effective Resistance of Isolated Nonmagnetic Rectangular Conductors." Both edge effect and skin effect must be considered to get reasonable results. The results of his calculation were presented in graph form for easy reference.

Professor T. J. Higgins then presented his paper "Theory and Application of Complex Logarithmic and Geometric Mean Distances." He derived his equations, explaining clearly each substitution and interpreted its meaning and use as he progressed.

The congested program did not allow sufficient time for C. A. Boddie, technical consultant in the office of the Chief Signal Officer, United States Army, Washington, D. C., to present "The Motional Mass of the Electron" (*EE, Jan '47, pp 45–60*), but it is hoped that it can be scheduled as soon as the summer general meeting.

Interconnected System Practice Reviewed

Before an enthusiastic group of 200, three papers on the subject of interconnected systems were presented at a conference sponsored by the AIEE committee on power generation and presided over by M. J. Steinberg (M '32) Consolidated Edison Company of New York (N. Y.), Inc. S. B. Morehouse (A '35) Leeds and Northrup Company, Philadelphia, Pa., in "Some Technical and Political Aspects of Interconnected System Operation" described the five major power pools existing in the United States. The largest is the so-called Midwest Power System extending east from the Mississippi River between Iowa and Illinois to Central Pennsylvania, south to the Gulf of Mexico and west to the Mississippi River. Operating in parallel with it is the Southwest Power Pool which extends west of the Mississippi to New Mexico and north to Nebraska. The Pacific Northwest area extends from the Pacific Ocean to the North Dakota border and south into Utah. Another interconnected system covers the industrial New York–New England area, while two other systems are located in the Pennsylvania–New Jersey–Maryland area and in the West Coast area.

Mr. Morehouse said that in many cases the basic objectives of given interconnections are not stated clearly by company administrations, with the result that these ties are operated from the standpoint of local internal political considerations instead of to gain over-all increased economy. To achieve the latter, the aim of a tie line must be stated clearly by management,

and operating personnel must be trained to carry out the policy.

It is recommended strongly that a system operator responsible for regulation of interconnected areas should devote his entire attention to this function and not be burdened with duties of local switching. A firm aid to smoother operation would be the centralization of all generating-station control, steam and electrical, in one common location, so that traditional departmental lines would disappear and the station operators work as a team. Only human inertia prevents realization of the tremendous gains to be made by this arrangement.

Mr. Morehouse stated that general engineering efforts must be exerted to make a broad study of basic objectives and establish a comprehensive program for more fully co-ordinating existing facilities on interconnected power systems.

OPERATION, PLANNING, PERFORMANCE

A conference paper, by R. E. Pierce (M '31) Ebasco Services, Inc., New York, entitled "Interconnected System Operation, Planning, and Performance" advised that, to guide tie line policies, an operating committee should be set up composed of various system representatives empowered to make decisions on their own authority; to carry out the plans of the operating committee, a co-ordinating technical staff must be organized. Both of these must be guided by establishment of broad fundamental policies by the managements concerned.

Major interconnection facilities can be planned to provide immediate flexibility, or with provision for future modifications, or in the final extreme to realize only a limited number of interconnection benefits. It is a mistake to provide inadequate communication facilities in order to hold down the first cost of an interconnection, Mr. Pierce declared. Telemetering equipment is of prime importance to realize full tie line benefits.

Procedures of operation include frequent and at least monthly meetings of the operating committee; written fundamental principles to guide operators; keeping records of loads, capabilities, reserves, maintenance schedules for aid in forecasting future needs and programs; establishing methods of interchange scheduling and accounting; and co-ordinated tests of governors and control equipment to arrive at optimum adjustments for best operation.

THE LINE CONTROL

In the technical paper, "Theoretical Approach to Speed and Tie Line Control," Robert Brandt (A '26) New England Power Company, Boston, Mass., outlined the basic principles of interconnected operation between electric systems. Frequency error indicates excess or deficient generation and varies directly with it; the relationship can be found experimentally. The amount of kilowatt-hour correction needed to bring system frequency to normal varies directly with the system capacity; this relationship is the fundamental principle on which the ordinary biased automatic tie line control works.

So-called free help from uncontrolled governors, said Mr. Brandt, may be a liability under some circumstances, because their speed corrections may be in the wrong direction to hold frequency and tie line load. Selective frequency control and cascade settings are only partial answers to tie line load control, as they cannot care adequately for all possible conditions.

Automatic operation with tie line bias, without any frequency controlling station, eliminates completely any difficulties that may arise with varying speeds of response of the different interconnected systems that may hamper other methods of control.

Mr. Brandt suggested that a blocking relay be used to prevent manual generation changes from being made in directions that increase frequency error; furthermore, he said, governors not under automatic tie line control should be relatively insensitive.

In the discussions that followed, most remarks concerned the latter paper. C. M. Metcalf, Consolidated Edison Company of New York, Inc., described the method of setting the bias control on the Consolidated Edison system and the company's method of operation.

It was pointed out that equipment is available to block manual impulses made in the wrong direction when adjusting frequency. This also can be applied to automatic control that may later supersede manual control.

Earle Wild (A '37) Commonwealth Edison Company, Chicago, Ill., described the company's general method of tie line control and showed examples of frequency variation with load. The first biased tie line control was installed in this country in 1939. He also pointed out that investment in governor equipment should be compatible with tie line control characteristics; it would be unwise to install governors of greater sensitivity than fundamentally needed.

E. E. George (F '36) Ebasco Services, Inc., New York, emphasized that most frequency changes are caused by manual block changes in load to keep automatic controls within their operating range. In his opinion, Mr. Morehouse's remarks should not be interpreted as a blanket indictment of all engineering administrations of interconnections, though undoubtedly some do not co-operate. He advocates installation of large adequate tie lines and close co-operation between all the departments concerned with their operation.

C. W. Mayott (M '43) Connecticut Valley Power Exchange, Hartford, stressed that this conference on interconnections should not be looked upon as indicating that poor operation is prevalent, but rather that operation is good but has room for improvement. He reviewed the operation of interconnections since the Utility Act of 1935, which caused some companies to discontinue ties across state lines to avoid dual government supervision—state commissions plus the Federal Power Commission—through the war to the present time. Co-ordination of systems is now better than during the war.

J. E. McCormack (F '44) Consolidated Edison Company of New York, Inc., said that, despite the title of Mr. Brandt's paper, the subject was treated from a very practical approach. He felt that the major work of the frequency control system is done within the dead band of the governors on the system, which is desirable.

A. P. Hayward (A '35) Duquesne Light Company, Pittsburgh, Pa., reviewed fundamental governor characteristics, especially as they affected tie line control. He said that steam operators must be trained thoroughly in the function and use of tie line equipment, but stressed the fact that, in the final analysis, supplying energy to customers is the main function, and interconnections play only a very minor part in such service. (*Report submitted by B. G. A. Skrotzki (M '45) secretary of the AIEE committee on power generation.*)

Large-Scale Computer Developments Discussed

C. Concordia (M '37) of General Electric Company, Schenectady, N. Y., opened the conference on large-scale computing devices, January 27, by remarking upon the rapid development of computers. This was an introductory meeting to present basic discussion of computers to date and logical expectations for their future.

Professor H. H. Aiken, in charge of the automatic sequence-controlled calculator at the Cruft Laboratory at Harvard University, Cambridge, Mass., opened his address by discussing the organization of large-scale computers. The basic ideas are not new. Computers must have three essential elements: the computing element, the storage element, and the recording element; control should be entirely automatic except for the statement of the problem. Computers should add, subtract, multiply, divide, refer to tables, interpolate these tables, and perform the functions represented by parenthesis and brackets, and they must be able to make certain choices and check their results.

The basic limitation at present is that of personnel because a problem must be examined and converted to a numerical system of equations, and the equations must be coded to be intelligible to the machine. This coding depends upon the character of the calculator. The automatic sequence calculator uses a 3-column paper tape on which perforations replace spoken commands. Time spent in coding is economic only if many values will be assigned to a parameter. The greatest present need is an automatic coder which may be operated like a typewriter. Chief advantage of the machine, of course, is its relatively high speed of calculation which saves time, manpower, and money. Another advantage is the fact that it automatically checks its results, which are delivered in a manner that is suitable for direct photography. This characteristic was utilized recently when the third, fourth, fifth, and sixth

order Bessel functions were calculated and photographed in book form in less time than it would have taken to proofread other types of reproduction.

PRINCETON COMPUTER

Julian Bigelow, chief engineer of the computer project at the Institute for Advanced Study, Princeton University, Princeton, N. J., described the computer which is in design there. The essential components of this device are the input organ for translating text into orders for the machine; two memory units; an electronic internal unit for numbers which must be rapidly available, and an external unit for storage of numbers; an arithmetic operator; a control unit to tell the machine what operation to perform at what time and in what sequence; and an output unit. A binary coding system was selected arbitrarily because of its easy representation by positive or negative signals. The external memory unit is a magnetic wire recorder, and the internal memory unit consists of 40 electronic tubes similar to iconoscope tubes. To reduce the number of vacuum tubes and maintain rapid operation, an Eccles-Jordan-type circuit was selected for the arithmetic element. This circuit is adapted to the transfer and shift operation used with binary numbers. The control circuit is still in the schematic stage, but the outstanding problem which must be solved is that of programing. An external memory unit should be developed which would afford instant readability in combination with high storage capacity.

IBM COMPUTERS

The history and use of difference engines for computation was discussed by J. C. McPherson, director of engineering, International Business Machine Corporation, Endicott, N. Y. Thirty IBM machines are in operation or on order for scientific and engineering computation. These machines can handle trigonometric, logarithmic, and exponential functions. Punched tapes are used for storage of tables, and punched cards are used to enter and extract information. The size of storage capacity of the improved multiplier, the relay calculator, and the electronic multiplier were discussed. Reliability, simplicity, economy, and ease of operations and ability will determine the type selected for a given problem.

ENIAC AND EDVAC

T. K. Sharpless (A '44) of the Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, described the ENIAC (electronic numerical integrator and computer) which is now in operation and the EDVAC (electronic discrete variable computer) which will be in operation within a year. The ENIAC was designed and built for the Ordnance Department of the United States Army for use in ballistics computations. The preparation of a set of ballistics tables required approximately two months' work by a staff of 25 persons. Most of this time was spent in reducing the equations to numerical form. The EDVAC is somewhat faster in arithmetical operations than the ENIAC. However, it will be about one fifth the size of ENIAC and contain only 3,000 vacuum tubes, one sixth the number contained in ENIAC. Data will be put in and taken out of the machine by means of pulses recorded on magnetic wire which will permit an increase in speed of 30 times over the punched card method. Coding of operations will be accomplished through use of a keyboard similar to that of a typewriter, and all the necessary numbers and instructions will be recorded directly on the wire.

MIT COMPUTER

The present development of a high-speed electronic digital computer at Massachusetts Institute of Technology, Cambridge, was described by J. W. Forrester (A '42) who is in charge of this computer project at the school's servomechanism laboratory. The computer will obtain a flexibility not now known because the setup of a new problem will be accomplished without physical change to the computer which will carry out its operations one at a time, and will be able to make alternate choices and insert computed results into the controlling program. The computer will have a storage capacity of 16,000 12-place numbers represented by 40 binary digits each. The speed at which the computer will work can be represented by the fact that it will multiply two 12-digit decimal numbers in less than 50 microseconds. Digits of a number will be transmitted simultaneously over 40 parallel busses from one part of the computer to another. The digit storage method will be the storage of positive and negative points of charge on a dielectrc insulating plate. High signal-to-noise ratio must be provided to ensure reliability and checking circuits must be available to detect and indicate improper operations. This computer will be particularly adaptable to nonlinear and discontinuous systems. The repeated solution of the same problem has definite application in the field of process control. It is anticipated that the setup time will be reduced through a library file of programs for generalized problems.

ALL-RELAY CALCULATOR

A relaying computing system developed by the Bell Telephone Laboratories, Inc., New York, N. Y., was described by S. B. Williams (F '26) who is switching development engineer at the laboratories. This system is tape driven, and information relating to function tables also is contained on punched tape. The calculator entails an all-relay circuit, which adds, subtracts, multiplies, divides, and extracts square roots. A teletype transmitter-distributor is employed as a reader to extract information from a tape and introduce it into a computer. One of the outstanding design features of the instrument is that two tapes are punched for input orders and a third tape punched by comparing these two, thereby permitting elimination of numerous errors. The control circuit of the system operates on a step-by-step self-checking basis, whereby a failure of operation stops the machine and preserves whatever numbers are stored or whatever relays are operated at the time. When the trouble is repaired, computation may be resumed with minimum loss of time.

DISCUSSION VARIED

H. R. Groesch of the Watson Laboratories at Cornell Univeristy, Ithaca, N. Y., pointed out that the lack of trained personnel was an outstanding problem. The extent of repair time, when the machine is not in operation, is another prime difficulty. He also pointed out that it might be worth while to use a decimal system so that the operator could interpret the results quickly. He agreed with Mr. Williams that the Bell alarm system for locating failure of equipment would be an extreme help. Mr. Bigelow mentioned that the truncation error in some problems might be appreciable. However, the machine itself may be used to compute the possible error. Harvard, Professor Aiken remarked, is anticipating the initiation of a graduate course in applied mathematics to relieve the acute personnel problem. The University of Pennsylvania also will offer a graduate course in mathematical computers next year. Each author pointed out that the outage time of his machine was not as great as Mr. Groesch had estimated; however, improvement of the per cent operating time is urgent. Professor Aiken said that by installing a "translator" at the input and output of a calculator the operator can use the decimal system while the machine operates on the binary system. This involves the use of 40 rather than 34 primary digits and it is feasible that the storage of these six extra digits upon future occasions might make a decided economic difference in operation.

Industrial Power Applications Diversified

S. F. French (M '39) of the Anaconda Copper Mining Company, New York, N. Y., presided at the technical session on industrial power applications January 30 at the winter meeting.

L. H. Berkley, formerly of the Engineer Training Center, Fort Belvoir, Va., in "An Analysis of Motor Selection for Brass-Slab Rolling-Mill Service," outlined some of the problems and calculations which he encountered in selecting a motor drive for a brass-slab rolling mill. It is noteworthy that the mill is of an old design, 1897, but has been kept in excellent running condition. The mill was driven originally by a Corliss steam engine. This was replaced in 1917 by a Westinghouse squirrel-cage induction motor, which has been driving the mill since that time for an average of 48 hours per week, living, as the author put it, "on borrowed time." The problems described in the paper came about in purchasing a replacement for this motor. The author discussed the several possibilities of different type motors, and then discounted some of them for reasons which he presented, picking out a high-slip motor as his final selection. Applications examined in the

paper can be adapted to many different types of applications, involving both new and existing installations.

R. T. Woodruff (M '43) of the Aluminum Ore Company, St. Louis, Mo., discussed the refining division of the aluminum industry for the benefit of engineers outside the industry in his conference paper, "Aluminum Ore Distribution Systems." Slides were shown of the load diagram and single line power diagram of a typical aluminum plant. Electrical loads vary from 7,500 kw for a two-million-pound per day plant up to 15,000 kw and more for larger plants. Corrected power factor is 90–95 per cent; load factor is 90 per cent; demand factor 35–40 per cent, while 65 per cent of the load is centrifugal pump motors up to 500 horsepower. Across-the-line starting is used up to 150 horsepower ratings.

MOTOR SPEED ANALYSIS

When a sudden load change occurs on a d-c motor operating at a given flux, a transient speed change results. Formulas have been available that allow calculation of the transient speed change, but which do not give as clear a picture of the effects produced by variation of certain factors as might be desired. Also, considerable labor is involved in calculating the transient speed change for a given set of values. F. E. Crever (M '45) of the General Electric Company, Schenectady, N. Y., in "An Extension of Impact Speed Drop Analysis" has extended the analysis of this study, in order that the calculation may be made easily. He first solved the transient speed change by two differential equations, plotting the results on charts. An explanation of the charts and how to use them was given, with clear examples shown. The conclusion drawn was that the charts give a simple and quick means of showing the speed change for impact loading, and they show that both low resistance and low inductance are important to obtain low impact speed drop. Several discussers spoke in behalf of this paper pointing out its usefulness, especially in applications in the steel industry.

GROUNDING SYSTEM

Eugene Herzog (M '29) of the United States Army Air Forces, Wright Field, Dayton, Ohio, in considering "A Selective Grounding System," gave reasons for the adoption of this type system and how it will be applied. The entire power system at Wright Field originally was operated ungrounded, but, with the coming of the war, power system interruptions became more frequent, and multiple failures appeared. Unscheduled interruptions at Wright Field, which is the Army Air Forces aeronautical development center, are serious, not only because of the possible damage to equipment, but also because of the need for repeating tests which have been interrupted at a cost of many thousands of dollars. Therefore, the grounding system is being put into service. As yet there has been no operating experience, but it is expected that continuous operation with a ground fault will be possible as soon as the fault current is reduced to a small value. This particular industrial setup is probably unique. The chance to schedule interruptions to clear ground faults is an operating advantage and will lead to a more economical system design with decreased duplicate equipment.

Aerial view of Wright Field, Dayton, Ohio, where a selective grounding system is being installed to minimize damage from a power interruption to equipment under test

CATHODIC PROTECTION OF TANKS

Since 1935, cathodic protection has been applied to more than 4,000 municipal and industrial water tanks in the United States and Canada. In "Cathodic Protection of Steel Water Tanks Using Aluminum Anodes," by L. P. Sudrabin of the Electro-Rust-Proofing Corporation, Newark, N. J., and R. B. Mears of the Aluminum Company of America, New Kensington, Pa., this subject was surveyed. Aluminum alloy anodes have been used for approximately 1,000 of these installations. It has been found that aluminum anodes develop a more uniform attack than do anodes of steel or stainless steel; that the loss of weight per ampere-hour of current passed from aluminum anodes is less than one third the weight lost from steel anodes; that the corrosion products from aluminum anodes are white or colorless, while those of anodes of other materials discolor or contaminate the water. Anodes of several aluminum-base alloys all have proved satisfactory in field installations.

Telephone Testing Described at Winter Meeting Conference

A conference on testing telephone receivers and transmitters was held on January 30 at the winter meeting with Arthur Bessey Smith (F '22) Automatic Electric Laboratories, Inc., Chicago, Ill., as chairman. The meeting, which was primarily a "talk-fest" to iron out difficulties among those present, was opened by Mr. Smith with a brief review of such testing in past years. The general objective of the telephone engineer is to make a good telephone which will perform well in the hands of the user. To ascertain whether or not the desired quality is being obtained certain tests are necessary. The early and most obvious comparison tests through standard cables, switching the circuit first to the unknown and then to a standard unit, required a means, a criterion of equality. The first criterion was mere loudness, then mental evaluation of combined loudness and clearness. Later, a nonreactive transmission line was used in place of the cable, and the decibel was employed as the unit instead of the mile of standard cable. Still later, the criterion was the immediate appreciation of short sentences, as well as of disrelated syllables. Finally, machines for testing telephone receivers and transmitters were developed and now are in general use both for design and for production control.

Discussion was initiated by "key" speakers who approached the subject from the standpoint of the user, the tester, and the manufacturer. Doctor Leo L. Beranek, Cruft Laboratory, Harvard University, Cambridge, Mass., speaking as an engineer wishing to design an instrument for a particular use, stated the general acoustic principles surrounding the transmission and reproduction of articulate speech. Doctor Beranek believes that only real-ear real-voice type of tests are satisfactory but because the response of earphone and microphone evaluated by a large number of people is too cumbersome for laboratory testing, he suggested the use of artificia ears and voices as satisfactory substitutes.

BUYER POSITION

The position of the buyer of such apparatus was presented by Raoul A. Faralla,

United States Army, for the Army, and P. M. Barzilaski for the United States Navy. Each described the tests which have been found necessary to insure adequate communication facilites during combat. These tests include shock tests, vibration tests, temperature and humidity tests, and salt spray tests.

W. L. Tuffnell, Bell Telephone Laboratories, Inc., New York, N. Y., as one concerned with the testing of telephone transmitters and receivers, described the artificial voice and ear, much used in testing objectively, without the subjective bias found in other tests. The artificial mouth should reproduce sound without appreciable distortion over the frequency range and pressure in question, should be reproducible, and should produce a sound field, distribution of which is about the same as the sound field in front of the human mouth. The artificial ear is built along the lines of the human ear and should have the same impedance and pressure sensitivity as the human ear. Resultant curves for the real and artificial ear are fairly close. However, as a tool this ear is complex and not easily produced and engineers have substituted the closed-type coupler which does not allow for leakage but is simpler.

MANUFACTURER POSITION

The standpoint of the makers of transmitters and receivers was set forth by a number of men representing manufacturers. Doctor George A. Brodie, Kellogg Switchboard and Supply Company, Chicago, Ill., described testing procedure in the Kellogg company, emphasizing testing of the parts before final assembly, while W. A. Codd, Stromberg-Carlson Company, Rochester, N. Y., concentrated on the testing of the granular carbon transmitter.

During World War II the Sonotone Corporation of Elmsford, N. Y., because of its experience with the manufacture of the delicate mechanism for hearing aids, contracted to manufacture miniature headsets for the Armed Forces which would be suitable for wear under battle helmets. These headsets, the receiver structure of which is just one half inch high and approximately the same diameter, had to meet extremely rigid requirements. Problems encountered by the Sonotone Corporation in the manufacture of the headsets, and the testing methods used, were reported by H. A. Pearson (A '41) of that company.

In England, where only one type of transmitter and receiver are in use, machine testing is a quality control test. According to L. C. Pocock, Standard Telephone and Cables, London, England, the important testing is done in the laboratory before the production stage and thus afterwards it is necessary only to maintain uniformity of the product. The only way it is possible to set an ideal standard, Mr. Pocock said, is to select the piece parts according to the mean value of the drawing, assemble them by hand, and by this method turn out five or six as near the mean as possible to be used as the standard for the product. One new method of testing in England introduced by the war is multiband testing which first was employed in the testing of the moving coil microphones used in Army tanks.

NEED FOR STANDARD

The final speaker, H. C. Pye (M '45), Automatic Electric Company, Chicago, Ill., expressed the opinion that a reference standard should be set up in articulation tests in place of the generally accepted absolute standard (percentage of perfect). This reference standard would have to be separate for transmitter and receiver. In the artificial ear test the voltage is given to the receiver and the response shown on a cathode-ray oscilloscope. The recommended procedure would be to manufacture an ideal product, find its limits and set tentative limits, take a sample of production, set the outside limits, test products at the extremes, and, as a result of this test, either widen the limits or discard the products at the extremes. The receivers are defined to a large degree by their mechanical construction, but the maximum and minimum limits may be set on an oscilloscope test for the flatness of the frequency response curve. Maintenance tests in the field are largely for resistance and noise in the microphone. The receiver is tested by the warble tone.

Informal discussion among the 30 or so members and guests in attendance closed the session.

Four Papers Presented at Symposium on Lightning

Field investigation and photographic studies of lightning were related at the symposium on lightning held Friday, January 31, and presided over by R. J. Wiseman (F '27) of The Okonite Company, Passaic, N. J.

The first paper, "Field Investigation of Lightning Surges at Substations," by I. W. Gross (F '45) of the American Gas and Electric Service Corporation, New York, N. Y., and G. D. McCann (M '44) of the California Institute of Technology, Pasadena, Calif., was presented by Mr. Gross. The original purpose of the investigation was to study the frequency, magnitude, and wave shape of the lightning currents discharged by lightning arresters in substations. The scope of the investigation later was increased to include the measurement of the crest surge voltages at the terminals of both the arresters and the transformers being protected. Probability curves of the average frequency, the crest magnitude, the effective fronts, and the duration of individual components of arrester discharge currents were shown on slides and explained. Mr. Gross summed up his presentation as follows:

1. The average frequency with which a single-pole arrester discharges varied from 0.2 to 6 times per year. Thirty per cent of the surge components were of positive polarity. The maximum recorded positive discharge current was 2,800 amperes. The maximum negative discharge current was 9,600 amperes.

2. The wave shapes of the lightning discharge currents were of the same general character as for direct strokes.

3. The wave fronts ranged from less than 0.5 microsecond to one maximum value of over 25 microseconds, but only 10 per cent exceeded 6 microseconds, with 80 per cent less than 2 microseconds.

4. There was indication that the arresters are supplying the required protection.

5. The necessity of locating arresters close to the apparatus they are intended to protect also was indicated.

PHOTOGRAPHIC STUDY

J. H. Hagenguth (M '44) of General Electric Company, Pittsfield, Mass., was the next to present his paper entitled "Photographic Study of Lightning." The lightning investigation in Pittsfield was started in 1935, he said, to obtain information on lightning strokes to open country, as a check or supplement to the Empire State Building investigation, and to obtain a large amount of statistical material concerning lightning characteristics. A cursory description was made on slides shown of the observatory, photographic equipment (multiple stroke camera), and auxiliary equipment.

Mr. Hagenguth stated that the principal results to be obtained from a photographic and visual investigation of lightning are multiplicity of strokes, duration of strokes, time interval between current peaks, continuity of strokes, current peaks, branching, leaders, cloud-to-cloud strokes, stroke height, and stroke density. He made comments on each and, in addition, touched upon an evaluation of storm days.

The conlusions drawn were enumerated: The photographic method provides a good tool to obtain a considerable amount of valuable statistical information on the characteristics of lightning strokes at minimum expense. It has been confirmed that a large number of strokes have long durations and that continuing currents are of frequent occurrence, both factors being important in the operation of transmission and distribution circuits. The investigation has shown that lightning phenomena in Pittsfield are of essentially the same characteristics as in other parts of the world.

ARRESTER DISCHARGES

Mr. McCann presented the next paper, "Field Research on Lightning Arrester Discharges," of which he and Edward Beck (M '35) of Westinghouse Electric Corporation, East Pittsburgh, Pa., were coauthors. A summary and analysis of all the data obtained in a study of the frequency, magnitude, and wave shapes of the lightning currents discharged by arresters, both in substations and on distribution circuits was presented. Because of the many variables and the fortuitous nature of lightning discharges, the data were collected and presented on a statistical basis.

The authors concluded the following:

1. Comparing the data on arrester discharges with the currents measured in direct strokes, it appears that the crest magnitudes and durations of arrester discharge currents are appreciably less than those in direct strokes.

2. The frequency with which the arresters in the stations discharge was found to be higher than for the distribution arresters, but the crest magnitudes, times to half value, and durations of the components in distribution arresters' discharges are greater.

3. There appear to be a considerable number of discharges with crest magnitudes or durations, or

both, less than the sensitivity of the fulchronograph which was used.

4. From the data obtained it is likely that some arrester discharges are of the multiple type with more than one component.

5. The data on distribution arresters indicated some important differences among systems.

6. The photorecorder data indicated that about 25 per cent of the components have durations equivalent to a half cycle at 60 cycles per second.

7. The duty on lightning arresters apparently varies from place to place and from year to year.

LEAKAGE CURRENT BURNS

In the paper, "Burning of Wood Structures by Leakage Currents," P. M. Ross (M '40) of the Ohio Brass Company, Barberton, stated that operating experience indicates that surface "tree" carbonization on crossarms and "pocket" burning at the crossarm-pole junction are the two general types of burn damage caused by fires of leakage current origin. Laboratory tests conducted on approximately 200 specimens indicate that a coincident occurrence of dry wood and selective wetting of pole and crosssarm surfaces by a precipitation which leaves dry high-resistance zones in series with the low-resistance wet sections of the leakage path can result in a fire of the pocket type. Shunting devices which by-pass leakage currents around dry high-resistance areas have proved successful in laboratory tests in eliminating pocket fires within the by-passed zone. Illustrations of pocket burns and diagrams of recommended shunts were shown. The selection of a final form of remedial device will be dictated by the initial cost of the device itself, and its expected life in relation to the structure it is protecting.

From their individual experiences, discussers cited their findings as compared with those presented in the papers and made suggestions pertaining to future investigations on lightning.

Machinery Problems and Theories Presented

C. P. Potter (F '29) Wagner Electric Corporation, St. Louis, Mo., introduced the speakers and the discussers at the technical session on electric machinery, January 31.

The first speaker, Gabriel Kron (M '45) General Electric Company, Schenectady, N. Y., explained his paper, "Equivalent Circuit of the Primitive Machine with Asymmetrical Stator and Rotor." In analyzing electric machinery engineers usually assume symmetry, that is, one space wave and one time wave varying sinusoidally. However, with unbalanced loads or other special conditions, operation is asymmetrical and several 2-pole waves exist in space. To make derivation of the equation of this case possible the conception of a primitive, or basic, machine is introduced. This primitive machine has two stator windings and two rotor windings; others may be added easily if necessary. If asymmetrical components exist, the system has three axes. The primitive machine is assumed to be standing still, but rotation merely varies the direct component resistances by a factor of one over the frequencies which actually exist. For special cases, such as a double-squirrel-cage synchronous motor with hunting, other motors, or harmonic supply voltage cases, the equivalent circuits of the primitive machine may be varied to meet these special conditions by opening certain circuits and interconnecting other circuits. The experienced engineer in this field obtains a "feeling" of flux flow and an artistic sense which eliminates the necessity of proving the resulting equivalent circuit. A. W. Rankin discussed practical results which he has obtained from this type of calculation, such as torque–slip curves, current–slip curves, and damper bar current for the asymmetrical and symmetrical machine.

TEMPERATURE MEASUREMENT

"Accuracy of Temperature Measurements on Coil Surfaces," by H. M. Beede and B. M. Cain (A '34) both of General Electric Company, West Lynn, Mass., presented the relationship between various methods of surface temperature observation for stator windings and the limits of accuracy for each method. For most nearly accurate results the resistance to heat flow between the surface of the coil and the measuring device should be a minimum and the resistance to flow between the device and the surrounding air should be a maximum. A 10-mil diameter thermocouple, a 20-mil thermocouple, and a conventional glass bulb thermometer were tested under various conditions. It was found that the 10-mil thermocouple imbedded in a special putty and covered by a felt pad gave readings that registered 99 per cent accuracy. The accepted method of temperature measurement proved to be less reliable than had been expected.

In the discussion which followed J. L. Fuller (M '45) Reliance Electric and Manufacturing Company, Cleveland, Ohio, reported experiments conducted with thermocouples placed on a brass strip whose temperature was varied. A 10-mil thermocouple produced very good results and he suggested such measurements could be substituted for standard resistance measurements. L. A. Kilgore (M '37) of Westinghouse Electric Corporation, East Pittsburgh, Pa. stated that under present standards the thermocouple should not be substituted for thermometer measurements, but perhaps should be allowed as a substitution for resistance measurements. The question was raised of measuring the temperature of rotating parts. Thermocouples are unhandy for such measurements because of the need for slip rings when the machine is in operation, and contact thermocouples applied at shutdown do not produce the greatest accuracy. Mr. Cain in closing stated that the revision of existing standards should be made in accordance with Mr. Kilgore's recommendation. He also discussed methods of measuring temperatures of rotating parts.

MAGNETOMOTIVE FORCE

J. M. Stein of Westinghouse Electric Corporation, Buffalo, N. Y. presented supplementary material to his paper "The Magnetomotive Force of 2-Layer Windings of Rotating Machines." This was of a mathematical nature, and he illustrated the use of his theory by practical examples. Professor J. F. Calvert (F '45) Northwestern Technological Institute, Evanston, Ill., complimented the resulting equation but questioned the advisability of deriving the magnetomotive force of a single conductor. Mr. Stein stated that the analysis had been made in this fashion to make it applicable to the squirrel-cage rotor.

LIQUID COOLING

The provocative subject of "Liquid Cooling of A-C Turbine Generators" was introduced by Carl J. Fechheimer (F '14) The Louis Allis Company, Milwaukee, Wis. He presented his design of a liquid-cooled generator using water in the stator, hydrogen in the air gap, and a noninflammable insulating liquid in the rotor. He explained the flow pattern through the generator, and presented the calculated temperature rise using several cooling media. Liquid cooling will bring about smaller volume for generators and higher capacity. Much discussion was presented concerning previously tested liquid-cooled or partially liquid-cooled machines which were abandoned, none of which were identical with Mr. Fechheimer's machine. The economics of such a system were discussed. It was pointed out that operating troubles might arise from the sacrifice of simplicity. However, the practicability of liquid cooling was predicted by some.

Merits of Grounding for Portable Equipment Debated

With the enormous increase in the use of portable electric tools and other equipments in manufacturing establishments, as well as in the home, it has become highly important that engineers concerned with the development, use, and maintenance of such equipment be thoroughly conversant with the best methods of making such equipment safe to use. At a symposium on grounding of portable electric equipment, presided over by Robin Beach (F '35) Robin Beach Engineers Associated, Brooklyn, N. Y., in the absence of L. F. Adams (F '42) General Electric Company, Schenectady, N. Y., the report on Grounding of Portable Equipment, of the Committee on Article 250 (National Electrical Code), Grounding, of the Electrical Committee, National Fire Prevention Association, was discussed by producers, installers, and users of connecting cord and plug equipment involved in such grounding.

The purpose of the symposium was to exchange information and opinions concerning methods of making portable electric equipment safe to handle, and, in particular, methods of providing effective grounding. The report discussed is a study of the grounding of noncurrent carrying parts of portable equipment. It contains statistical data on electric shock,

analysis of such data, and recommendations based on this analysis.

A. H. Schirmer (M '29) Bell Telephone Laboratories, Inc., New York, N. Y., chairman of the committee which assembled the report, illustrated the problem of grounding portable equipment by three typical cases. From his study of the problem he has concluded that there is no dispute that well-insulated equipment will provide superior protection to metal shells and grounding, but that certain equipment should be grounded. When equipment is grounded, the grounding should be automatic. He noted, as did a number of other discussers, that there is evidence of confusion between the "hot" and the grounding prongs. He suggested that the grounding prongs and terminals in devices should be distinctly different from the prongs and terminals carrying current.

E. E. Turkington (A '08) Associated Factory Mutual Fire Insurance Company, Boston, Mass., was interested, as was Mr. Schirmer, in the fact that grounding often does not prevent accidents and, in fact, may cause them. The danger lies in ignorance of the proper use of grounding on the part of the user, or in grounding which has broken off or has been destroyed. He expressed the belief that grounding is necessary for safety and that 440- and 550-volt portable tools should have automatic grounding. E. W. McLeod, Hydro-Electric Power Commission of Ontario, Canada, described work in this field in Canada. According to the Canadian Electrical Code portable electric devices are required to have noncurrent-carrying metal parts grounded and specifications are set up by the code. Furthermore, there must be provision for automatic grounding. The weak link in electrical installations, according to Mr. McLeod, is the flexible cord which is a contributing factor to fatalities. Thus, standards must be kept as high as is practicable. Adequate installations, of course, provide protection, but as it is hard to define adequate installations, it is necessary to fall back on grounding. The bottleneck is the receptacle which, in general, is two holed, and therefore is unable to accommodate the 3-prong plug which provides for grounding.

One of the main points at issue was the comparative degree of protection afforded by insulation as compared with grounding. The consensus seems to be that under present conditions, especially with devices used in the home, insulation is a better choice, if maintained properly. However, grounding is essential for protection under many conditions, and provision should be made for it. H. H. Watson, the General Electric Company, described a plug providing for grounding which has been designed according to the recommendations of the report. Such a plug, as recommended also by other discussers, would have three prongs, the one for grounding to be of a distinctive color. Unfortunately, an adapter would have to be provided for use with 2-contact receptacles during the transition period. B. B. Ramey (M '22) Black and Decker Manufacturing Company, Towson, Ind., objected to the use of the adapters as a nuisance. He suggested that the 3-hole receptacle and the 3-prong plugs be made mandatory under the National Electrical Code.

An interesting note was supplied by H. B. Fuge (M '43) Diehl Manufacturing Company, Finderne, N. J., who has had recent access to regulations on the subject in Great Britain, Norway, and Sweden. Mr. Fuge said that in these countries emphasis is placed on insulation to protect the user because of the difficulties of grounding the 240-volt equipment which is in general use. In Norway and Sweden double insulation is required. For test purposes, a test finger, a conducting probe the size and shape of a human finger, is used to probe the entire apparatus to make certain that it can reach no section which might be a source of danger.

A review by W. R. Smith (F '30) Public Service Electric and Gas Company, Newark, N. J., of the main points brought out by the various speakers preceded a short discussion.

Power Transmission Problems Presented at Technical Session

R. J. Wiseman (F '27) of The Okonite Company, Passaic, N. J., chairman of the technical session on power transmission on January 31 at the winter meeting, introduced the first speaker by pointing out the importance of weather on power transmission and the necessity of co-ordination of weather bureau reports. "Meteorological Engineering for the Electric Utilities," by Harry A. Downs, United States Weather Bureau, Chicago, Ill., stressed the necessity for stimulation of interests in possible usage of weather bureau information, encouragement of co-ordination of the weather services, and the desirability for more research. Efforts are now made to report each storm occuring in the United States and to study its character. Effect of the weather on electric equipment operation and on consumer demand is partially known, but more investigation is needed. The speaker emphasized six important steps to improve the weather bureau service and its utilization: frequent liaison visits between utilities and the weather bureau; encouragement of system-wide distribution of forecasts; development of a thunder storm recording; continued development and standard calibration of a light intensity recorder; encouragement of practical and experimental research; and sponsorship of utility forecast specialists who will understand the needs of the utilities and the interpretation of the weather bureau reports for work, both with government agencies and power companies.

In the discussion which ensued, the co-operation between the Commonwealth Edison Company of Chicago and the Chicago Weather Bureau was emphasized. Particular use is made of the daily precipitation reports, which are used to determine the time when washing or inspection of the system insulators is necessary or advisable. Similar co-operation exists between the New York Weather Bureau and the Consolidated Edison Company of New York. A teletype machine is installed in the New York system operator's office to insure direct and prompt communication with the weather bureau in times of emergency. For completely hydroelectric systems such as exist in Canada, long range forecasts are necessary and valuable. Especially helpful would be forecasts of precipitation in the summer and temperature in the spring, neither of which is now available.

CALCULATION METHOD

P. C. Magnusson (A '38) Washington, D. C., presented "The Transient-Energy Method of Calculating Stability." This is a conservation-of-energy method for calculating system stability conditions and is an extension of the equal-area method. Typical terms of solution were shown and their result interpreted. The method probably will not replace but rather supplement the step-by-step method of calculation.

CORONA INVESTIGATION

In his paper "Internal Corona Discharges in Insulated Cables," E. W. Greenfield (M '37) of Anaconda Wire and Cable Company, Hastings-on-Hudson, N. Y., described a circuit which detects and measures the volume of corona discharge in cables. Operation of this tester, which is an improvement on existing equipment, is based upon the principle that an extremely rapid voltage rise occurs, which produces a square-wave transient on the cable, when corona forms. By detection of the higher harmonics of this transient the presence and volume of ionization can be determined. Sample test data and oscilloscope traces were shown. The discussers challenged some interpretation of the data, but the practicability and usefulness of the method were supported. It was pointed out that such a method easily might have other applications, such as insulation testing of rotating machines. Other similar corona testing circuits were described.

The Bonneville Power Administration has been conducting tests to determine whether or not they can effect economies without affecting the quality of service rendered. H. L. Rorden (M '36) of Bonneville Power Administration, Portland, Oreg., described some of these investigations in his paper, "Radio-Noise Influence of 230-Kv Lines." Many predictable data were obtained, but some unexpected phenomena resulted: corona radiation varies directly with the voltage of the line, the increase being more rapid at higher voltages; noise level varies inversely with the distance from the line; corona radiation did not decrease substantially with increasing line age; corona radiation increases during storms, although the storm area may not be directly over the testing position; at a smaller conductor separation than previously had been used the corona loss was less; and radio interference was found to be greatest at frequencies near the lower end of the standard broadcast band.

It is predicted that radio interference will not be the determining factor in the design of high-voltage lines. A. E. Davison (M '44) of Hydro-Electric Power Commission of Ontario, Canada, in his discussion presented several questions about the paper and its results which had been asked by students and cadet engineers of the Hydro-Electric Power Commission. Mr. Rorden replied that some of the questions were of the nature that would require further study, and that he would answer them in his formal closure.

New Devices and Control for Industrial Use

A technical session on industrial instrumentation and control combined the efforts of two groups at the winter meeting on January 31. M. Michel (A '39) Aluminum Company of America, Pittsburgh, Pa., introduced speakers on the first part of the program which had to do with instrumentation. Herbert Speight (M '21) Westinghouse Electric Corporation, New York, N. Y., took over after the discussion on instrumentation and introduced the speakers who presented papers on control.

TRENDS IN INSTRUMENTATION

According to H. D. Middel, of General Electric Company, electronic development has made itself felt by opening the field for new primary sensing elements, improved measuring circuits, calculation networks and controllers. Indirectly, the introduction of electronic technique in certain cases has given process designers new latitude which has led toward more nearly optimum design for varied uses. New sensing elements continually are being developed which are capable of detecting physical properties of materials—properties that heretofore have defied industrial measurements. It is in the direction of more nearly qualitative measurements that electronic instruments will have their greatest influence. Instrument designers have placed in the hands of process operators measuring tools of great potential importance, the real value of which will not be known until the operators are willing to go more than halfway in applying these new instruments. For those measurements now satisfactorily accomplished, it provides methods for reducing measurement lag and a more or less universal measuring circuit for all quantities.

Applications that are difficult to control manually are usually easy to control automatically and vice versa. As industry grew and new measuring tools were developed, the recorder or indicator was used to initiate control response. This control response always is delayed by the time constant or lag coefficient of the measurement servomechanism. As processes were speeded up, the tendency was to make the recorder grow faster in response, but a practical limit is imposed for operation in system maintenance. It is concluded, therefore, that the ultimate equipment from the standpoint of accuracy and speed of response will be a combined electronic and pneumatic controller. In the place of the conventional wide chart or round chart paper-type recorder, wire recorders may provide a means for recording plant performance, with audio-tone signals whose frequency is a measure of deviation.

GAUGES FOR QUALITY CONTROL

Joseph Manuele (M '44), Westinghouse Electric Corporation, East Pittsburgh, Pa., presented "Use of Electric Gauges in Quality Control," in which he listed four ways in which electricity can be used for accurate measurement which are: in light sources; in magnetic circuits; in electronic tubes; and as wave energy. The most valuable use of electric gauges is not for the determination of a dimension after a part has been finished, but for control of the production of that dimension. Electric circuits for determining and controlling the quality of products produced by industry only have begun to be used, and a number of problems still remain to be solved. The problem of measuring odors, analysis and measurement of noises, measurement of contours, matching of colors, and measurement of female threads are but a few of the problems to be solved.

At present, there is no other tool which adequately could replace wave energy, such as X rays or supersonic instruments for locating and exploring hidden defects in castings, forgings, and molded parts. But X-ray examination and the use of supersonic instruments are both post-mortem operations and cannot be used to *control* quality. Corrective measures can be taken only in subsequent production.

MICROWAVE TECHNIQUE

The term "radar" in the paper, "Radar Technique in Industrial Control" by W. D. Cockrell (M '43) General Electric Company, Schenectady, N. Y., may be misleading. However, circuits such as square-wave generators, clippers, blocking, timing, and counting circuits normally associated with radar have an equally important place in industrial electronic circuits. The author explained a typical industrial application used in the paper and printing industry in slitting and processing machines where accurate alignment is required. A photoelectric scanning head is set up so that correct register position is obtained. One of the first radar applications in utilization of the photoelectric tube signal is to use it to trigger a square-wave circuit. In the error detection circuit a principle somewhat like that used to match the plan-position-indicator sweep to the antenna position is employed. Several other applications to the same installation were given. Elementary electronic tube circuits familiar to the radar man are not limited to one field only, but can be combined and arranged to serve many functional requirements.

TUBELESS AMPLIFIER

Need for a shockproof amplifier without vacuum tubes led to the development of a unit described in "A Balanced Amplifier Using Biased Saturable Core Reactors" by H. S. Kirschbaum (A '43) Ohio State University Research Foundation, Columbus, and E. L. Harder (M '41) Westinghouse Electric Corporation, East Pittsburgh, Pa. Study was first made of the conventional saturable core reactor in a miniature size, and it was found that the small 0.4-milliwatt d-c signal was insufficient excitation to produce enough flux density to have any material effect on the a-c legs. Answer to the problem was found in the form of a balanced amplifier design. The amplifier includes the following features:

1. True d-c amplifier, with no lower frequency limitation.
2. Complete conductive isolation of input and output circuits.
3. Operation to low input signals to the order of 0.4 milliwatts.
4. Amplification practically independent of a-c supply variation.
5. Amplification practically independent of bias supply variation.
6. Shockproof.
7. Unlimited life, no vacuum tubes.

Possible applications of the device might be in street lighting control actuated by carrier current, or in voltage regulators. In the discussion which followed, the effect of hysteresis was considered and was determined to be negligible. D. Van Reis, who is traveling throughout the United States on an American–Scandinavian fellowship, mentioned that amplification factors of 250,000 had been attained in Sweden with spiral cores to reduce leakage.

CIRCUIT BREAKER PROTECTION

R. R. McGee (A '28), The Trumbull Electric Manufacturing Company, Plainville, Conn., presented "Notes on Circuit Breaker Protection for Industrial Equipment." The tremendous supply of unskilled labor during the war emphasized certain features of circuit breakers, such as quick resetability and no exposed live parts.

These features were tempered with other factors, which experience has shown, for guidance in future improvements. The circuit breaker used for protection of low voltage motor starter circuits should be expected to do that alone. It is primarily a circuit protective device, and not a motor overload device, lightning arrester, or timing relay. This points up the need for even closer co-ordination between motors, controller, and circuit breakers. The Institute can serve a most useful purpose in bringing the manufacturers of these items together to solve the problems of co-ordination, selectivity, and safety, according to Mr. McGee.

New Design Methods for Capacitor Motors

New National Electrical Manufacturers Association fractional-horsepower motor standards, new design methods for the design of capacitor motors, and the multistage Rototrol were the topics at the technical session on electric machinery, January 31, presided over by M. S. Oldacre (M '42)

of the Commonwealth Edison Company, Chicago, Ill.

STANDARDS

In "New NEMA Fractional-Horsepower Motor Standards; Their Effect on Refrigeration and Pump Application," C. P. Potter (F '29) of the Wagner Electric Corporation, St. Louis, Mo., described a logical method of rating fractional-horsepower motors on the basis of breakdown torque. This information is compiled in a table which supplies the purchaser of a motor with the breakdown torque that may be expected from motors of a given horsepower rating. It has been recommended by NEMA that the service factor of the motor shall be marked on the name plate in addition to other name plate information. Tables of locked rotor currents and code letters which have been NEMA Standards also were included in this standardization. The new standards were adopted to promote a more logical design and application of fractional-horsepower motors in order to serve the best interests of both the customer and motor manufacturer. (*EE, Nov '46, p 541 and EE, Dec '46, p 592*).

CAPACITOR MOTOR DESIGN

For those motor manufacturers concerned with the design of capacitor motors, two papers were presented, both of which should be of great interest to the engineer who designs capacitor motors. In "The Equivalent Circuit of the Capacitor Motor" by S. S. L. Chang (Student Member) of Robbins and Myers, Inc., Springfield, Ohio, an equivalent circuit of the capacitor motor is derived from which the performance curve can be calculated within a few hours. Mr. Chang also set up equations for solving the maximum torque and efficiency of capacitor motors, to be used as a starting point for design. He substantiated his presentation with both calculated and tested performance curves. P. H. Trickey (M '36) Diehl Manufacturing Company, Finderne, N. J. who has had vast experience in capacitor motor design, in a discussion asked the author several pertinent questions.

In "A Design Method for Capacitor Motors," by T. C. Lloyd (M '46) and S. S. L. Chang (Student Member) both of Robbins and Myers, Inc., a method was introduced for the permanent switch capacitor motor, whereby the main winding can be designed directly to yield a desired maximum torque. Derivations based on the equivalent circuit shown in Mr. Chang's previous paper disclosed the fact that the maximum torque of a capacitor motor is relatively independent of the auxiliary winding. The designer, with a specified maximum torque, can fix the main winding for this given torque, select the size capacitor to be used, and with this knowledge, read directly from curves illustrated in the Chang and Lloyd paper the turns per coil of the auxiliary winding.

MULTISTAGE ROTOTROL

M. M. Liwschitz (M '39) of the Polytechnic Institute of Brooklyn, N. Y., and also consulting engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa., in "The Multistage Rototrol" showed that under certain conditions a d-c machine may be adapted to operate with more than two stages of amplification having various pole ratios. A 3-stage amplifier was described in detail, and two different coil arrangements for this amplifier were shown. The behavior of the 3-stage amplifier under transient conditions was investigated.

Gas Pressure and Ocean Cables Feature Communications Session

A co-ordinated group of four technical papers were presented to an audience of almost 200 at a session on communications components and techniques on January 31 during the winter meeting with J. J. Pilliod (F '34) chairman of the AIEE committee on communication, presiding. Despite their dissimilar titles, the papers are related by their relation to various aspects of communication, describing central offices, the cables to connect them, transmission of telegraphy by radio and wire, and the spanning of oceans.

AUTOMATIC SWITCHING SYSTEM

A newly developed switch called the *XY* for use in step-by-step dial telephone systems was described by H. R. Reed (M '34) chief telephone engineer of the Stromberg-Carlson Company, Rochester, N. Y. The switch is named *XY* because in operation the moving contacts move first to the right and then away from the observer. The one switch, which is a flat type, may be used to perform the functions of line finding, selector, or connector; not all contacts are used in each of these functions, but the unit has been standardized in this way for interchangeability. The components are plug and jack mounted, and 50 switches form one complete unit. These package-type units may be assembled and subsequent additions and rearrangements made according to the number of lines required for the installation. Only one set of soldered connections is required for the unit of 50 switches.

Samples of the switch and of the wire banks with which it is associated were exhibited by Mr. Reed. In reply to a question asked in the discussion of the paper, he stated that automatic exchanges using this equipment are operating in Rochester, N. Y., and in Mexico, Federal District, Mexico.

GAS PRESSURE FOR TELEPHONE CABLES

The importance of avoiding interruptions to service was discussed by Mr. Pilliod as he introduced the second paper at the session, recalling a recent experience he had with a railway train that stalled because of mechanical failure and inconvenienced a large number of people. Trouble records of long telephone cable lines have shown a great decrease in interruptions during during recent years, and this improved service was attributed largely to the introduction of gas-filled cables. In his paper R. C. Giese (M '32) division plant superintendent of the American Telephone and Telegraph Company, New York, N. Y., described the effectiveness of the gas, which is dried nitrogen, in preventing the entrance of moisture through any leaks that may occur in the sheath and in aiding the location of points of damage. The fall of pressure, of course, serves to give an alarm. Various curves were shown which illustrated how accurately the location of the damage could be found by measurement of the pressure gradient along the length of the cable.

Since its introduction about 1926, the use of cable operating under pressure has been extended until practically all underground and aerial toll cable in the United States now is of this type.

During the discussion of the paper, it was stated that the gas blocks which divide the cable into separately pressurized sections of lengths of about 60,000 feet may be by-passed readily with a small pipe if it is desirable to permit circulation of the gas between sections. Loss of the normal 9-pound-per-square-inch pressure at the rate of 1 or 2 pounds per square inch per month, is considered a small loss, and the necessity for recharging once in three or four months does not justify any action to reduce leakage.

FREQUENCY SHIFT TELEGRAPHY

A paper, "Frequency Shift Telegraphy—Radio and Wire Applications," by J. R. Davey and A. L. Matte (M '36) of the Bell Telephone Laboratories, Inc., New York, N. Y., was presented by Mr. Davey. This method of telegraphy, which found wide applications during the recent war, is based on maintaining a carrier of constant amplitude and shifting it between two frequencies. It is particularly advantageous for high frequency radio circuits because it can accept rapid level changes and offers an improved signal-to-noise ratio.

The improvement to be gained by changing from the amplitude modulated to a frequency shift system depends on the noise level and eventually is governed by the economics of the change. With wide changes in the level of the received signal, frequency shift telegraphy is said to be superior.

Following presentation of the paper, F. B. Bramhall (F '44) of the Western Union Telegraph Company, New York, N. Y., raised the question of the difference in meaning, if any, between frequency shift and frequency modulation. He stated that the data in the present paper support other data gathered several years ago. It was brought out that the Western Union Company has converted its facilities to frequency modulation, but that the Bell System has not as yet made any actual applications of frequency shift to its wire plant, because there is no marked advantage on stable circuits and it is undesirable to make wholesale changes at this time.

Commenting on the question of terminology, Mr. Pilliod remarked that much confusion could have been caused at early meetings if the simple on-and-off action of a switch had been referred to as modulation.

A brief review of the history of telegraphy was given by Lloyd Espenschied (F '30)

consultant of the Bell Telephone Laboratories, to show that there has been a continuous evolution for more than a century and that a beginning at any one time with any one man cannot be established.

OCEAN CABLE TELEGRAPHY

C. H. Cramer (M '34) of the Western Union Telegraph Company, New York, N. Y., started the presentation of his paper "Some Modern Techniques in Ocean Cable Telegraphy," by recalling that at an AIEE meeting 25 years ago it was predicted that ocean cables faced early obsolescence because of the coming of radio. However, because of certain transmission advantages and continuing improvement, cables are far from being abandoned.

In contrast to the ultrahigh frequencies now mentioned so commonly, ocean cables operate on frequencies not exceeding approximately 20 cycles per second. A 2,000-mile length of cable has a capacitance of 800 microfarads and a resistance of 3,000 ohms with attenuation approaching 100 decibels, but a printer may be operated at 500 letters per minute. Such performance is made possible by the terminal equipment used with the cable and by the present methods of accurately balancing circuits.

By taking as a criterion the number of letters per minute that can be transmitted per cycle of band width, which in this instance is 25, cables can be shown to be the most efficient of all means. New and improved insulations promise further improvement, and Mr. Cramer concluded that cables remain an active competitor to radio communication.

The continuity of service of cables was cited by I. S. Coggeshall (M '37) of the Western Union Telegraph Company, who stated that one cable from New York to London has been operating practically continuously since 1938 at 400 words per minute. Admittedly, however, some interruptions on cable circuits may last for months. He described briefly the service rendered by cable circuits during the recent war, when instantaneous communication up to the capacity of the circuit was rendered to widely separated offices.

Board of Directors Acts on Collective Bargaining at Winter Meeting

The president of AIEE was authorized to take action as he sees fit to secure a revision of the National Labor Relations Act that will give engineers freedom of choice in collective bargaining, at a meeting of the AIEE board of directors held January 30 at Institute headquarters.

Action of the board followed presentation of a report by the committee on collective bargaining and related matters. After a discussion of possible joint action, to make the engineers' position known to Congressional groups currently considering revision of the Wagner Act, it was decided to empower the president to act at his discretion. The following resolution was adopted by the board:

RESOLVED that the President hereby is empowered, in his discretion, to proceed in efforts to bring about a revision of the National Labor Relations Act which will secure for engineers freedom of choice in the matter of collective bargaining.

APPROPRIATIONS

Appropriations were made to cover a contribution of $400 for the Radio Technical Planning Board and for membership dues of the Canada District in the Canadian Radio Technical Planning Board to an amount not in excess of $100; also for a contribution at the rate of 15 cents per member in District 10, to the Canadian Council of Professional Engineers and Scientists, plus an estimated $200 for traveling expenses, making a total of approximately $325; and for payment of dues to the United States National Committee of the International Commission on Illumination amounting to $300 (prewar dues), an increase from the $150 war dues.

Additional appropriations were made for publications for the balance of the appropriation year to cover an increase in printing rates, effective March 1947, amounting to an estimated $7,000, and an increase of $3,400 in the cost of text paper.

Higher prices of Institute badges were authorized to offset increased costs.

Authorization was given for the usual travel expense allowance in connection with a joint conference on student activities of Districts 8 and 9 and the University of British Columbia Branch, during the 1947 Pacific general meeting in San Diego, Calif.

PLANNING AND CO-ORDINATION COMMITTEE

In view of the provision in the bylaws of the National Electronics Conference for AIEE representation on its board, and upon recommendation of the committee on planning and co-ordination, authorization was given for the appointment of such representative annually by the committee on electronics, such appointment to be reported to the board of directors and included in lists of Institute representatives published in the Yearbook and elsewhere.

Upon recommendation of the committee on planning and co-ordination the president was authorized to appoint a small committee to make a study of the possibility of modernizing the headquarters office methods, equipment, and lighting.

The committee on planning and co-ordination reported recommendations resulting from its study of a proposal by the Engineers' Council for Professional Development for uniform grades of membership in various societies. The board approved the recommendations, which were to the effect that the board approves in principle the adoption of uniform grades of membership and submission of certain proposals to the engineering societies concerned for consideration.

A report of the subcommittee on professional activities of the committee on planning and co-ordination of its study on the organization of the engineering profession was presented. The board referred the report to a special committee consisting of the president and the four junior past presidents of the Institute for review and recommendations as to appropriate action on, or disposition of, the report. Authorization was given for early publication of portions of the report in *ELECTRICAL ENGINEERING*, with a suitable prefatory statement by the special committee to which the report is referred, and for immediate publication in *ELECTRICAL ENGINEERING* of the statistical results of the opinions expressed by over 1,000 members on the questionnaires, as well as for the release to each participating District and Section group of the results of the questionnaires they submitted.

TECHNICAL SUBCOMMITTEE

A report was presented by the technical activities subcommittee of the committee on planning and co-ordination. In its plan for the association of technical committees in groups, each group to have a co-ordinating committee, the subcommittee recommended an expansion of the industry group from four to seven technical committees by the creation of three new technical committees. It suggested a change in name of two of the existing committees and submitted proposed scopes of activity for the seven technical committees in this group. The board approved these recommendations. The new committees thus established are:

Committee on electric heating.

Committee on mining, metal forming, and rolling.

Committee on machine tools, material processing, and fabrication.

The new names of committees are:

Committee on industrial power systems (formerly, committee on industrial power applications).

Chemical, electrochemical, and electrothermal committee (formerly, committee on electrochemistry and electrometallurgy)

Upon recommendation of the technical activities subcommittee, the board voted to transfer the committee on education from the classification of a technical committee to that of a general committee, thus providing a broader field for its activities. The chairman of the committee on education will be a member, ex officio, of the technical program committee.

BYLAW AMENDMENTS

Amendments to the bylaws of the Edison Medal committee were approved, which provide for making the award before the

15th of November instead of in the second week in December as heretofore.

Amendments to the bylaws were adopted as follows:

1. Section 27 amended to indicate the four general meetings of the Institute as winter general meeting, summer general meeting, Midwest general meeting, and Pacific general meeting.

2. The word "meeting" substituted for the word "convention" wherever occuring in the bylaws.

3. Following note added to the map just left of the California coast: "District 8, San Francisco Section, also includes the Territory of Hawaii."

4. Section 48 amended to provide, in addition to the $200 basic allotment to each Section, an allotment of $100 to the Section for each of its Subsections holding regularly scheduled meetings, and increasing the additional amount allotted to Sections for a larger number of regularly scheduled Section, Subsection, and technical group meetings held during the preceding fiscal year (ending April 30) to read as follows:
12 to 17 meetings, $50.
18 to 23 meetings, $100.
24 to 29 meetings, $150.
30 or more meetings, $200.

5. Section 53 was amended to provide for extension of the term of Student membership until a Student member has reached the age of 21 and is therefore eligible to become an Associate, to cover the occasional case of a Student graduating before he is 21.

6. Sections 64 and 61 were amended to provide for joint Student Branches of AIEE and certain other engineering societies and to define the duties of the Branch counselor in such cases.

7. Section 33 was amended to make it possible in Districts of less than five Sections for the District executive committee to function as the co-ordinating committee for the District and to clarify some ambiguities in the section.

FUTURE MEETINGS

The 1948 summer general meeting, previously authorized to be held in Mexico, Federal District, was canceled by adoption of the following resolution:

RESOLVED that the directors of the Institute, recognizing that the burden of effort and expense involved in organizing and conducting a general meeting in Mexico in the summer of 1948 would be heavier than our Mexican members could be expected to bear, and further recognizing that existing economic conditions would prevent many of our most active members in the United States and Canada from participating, believe it wise to postpone the holding of such a meeting until some more propitious time. They reach this decision with sincere regret and with an earnest hope that general conditions will become more favorable to the desired meeting in the early future.

The vice-presidents were requested to explore the possibilities of holding the 1948 summer general meeting in their Districts and to report to the executive committee for action any invitations that may be received.

A schedule of future meetings, submitted by the committee on planning and co-ordination, was adopted as follows:

General Meetings

1948 Pacific —Referred to vice-presidents of Districts 6, 8, 9, and 10 for recommendations regarding dates and location.

1948 Midwest—Milwaukee, Wis., October 18–22.

1949 winter—New York, N. Y., January 24–28.

1949 summer—Swampscott, Mass., June 20–24.

1949 Pacific—San Francisco, Calif. Vice-president of District 8 (Pacific) to determine dates.

1949 Midwest—Referred to vice-presidents of Districts 4, 5, and 7 to recommend location and dates.

1950 winter—New York, N. Y., January 23–27.

1950 combined summer and Pacific—Los Angeles, Calif., dates to be decided by local officers.

1950 Midwest—Dates and location referred to the vice-presidents of Districts 4, 5, and 7 for recommendation.

District Meetings

1948 District 7—Oklahoma City, Okla., April 21–23.

1948 District 4—Birmingham, Ala., November 3–5.

It was decided to hold the 1947 annual business meeting of the Institute in Montreal, Quebec, Canada, on Wednesday, June 11.

Secretary H. H. Henline was appointed the official delegate of the Institute at the 75th anniversary celebration of the American Institute of Mining and Metallurgica- Engineers, March 17–19, 1947, at the Waldorf-Astoria Hotel, New York, N. Y.

It was decided to hold the next meeting of the board of directors in Worcester, Mass., during the North Eastern District meeting.

AIEE REPRESENTATIVES

Joseph W. Barker (F '30) and I. Melville Stein (F '39) were reappointed representatives of the Institute on the council of the American Association for the Advancement of Science for the term of two years beginning January 1, 1947.

The president was empowered to appoint a representative on the Hoover Medal Board of Award for a term of six years, and to appoint a member of the Institute's board of directors as a member of the committee on international relations of the Engineers Joint Council.

Recommendations adopted at meetings of the board of examiners on November 21, and December 19, 1946, and January 16, 1947, were reported and approved. The following actions were taken upon recommendation of the board of examiners: 9 applicants were transferred to the grade of Fellow; 37 applicants were transferred and 37 were elected to the grade of Member; 208 applicants were elected to the grade of Associate; 282 Student Members were enrolled.

Monthly expenditures from general funds were reported and approved, as follows: November 1946, $44,118.71; December 1946, $44,644.38; January 1947, $40,530.22.

Present at the meeting were:

President—J. Elmer Housley, Alcoa, Tenn. *Past Presidents*—W. E. Wickenden, Cleveland, Ohio; C. A. Powel, East Pittsburgh, Pa. *Vice-Presidents*—O. E. Buckley, New York, N. Y.; R. F. Danner, Oklahoma City, Okla.; E. W. Davis, Cambridge, Mass.; F. F. Evenson, San Diego, Calif.; F. L. Lawton, Montreal, Quebec, Canada; T. G. LeClair, Chicago, Ill.; L. M. Robertson, Denver, Colo.; H. B. Wolf, Charlotte, N. C. *Directors*—P. L. Alger, Schenectady, N. Y.; J. F. Fairman, New York, N. Y.; J. M. Flanigen, Atlanta, Ga.; R. T. Henry, Buffalo, N. Y.; C. M. Laffoon, East Pittsburgh, Pa.; M. J. McHenry, Toronto, Ontario, Canada; C. W. Mier, Dallas, Tex.; S. H. Mortensen, Milwaukee, Wisc.; J. R. North, Jackson, Mich.; D. A. Quarles, New York, N. Y.; Walter C. Smith, San Francisco, Calif.; E. P. Yerkes, Philadelphia, Pa. *Treasurer*—W. I. Slichter, New York, N. Y. *Secretary*—H. H. Henline, New York, N. Y.

(Left to right) Shown with AIEE President J. Elmer Housley at the 1947 winter meeting are AIEE Vice-Presidents R. F. Danner, O. E. Buckley, L. M. Robertson, T. G. Le Clair, Mr. Housley, E. W. Davis, H. B. Wolf, F. L. Lawton, and F. F. Evenson

Institute Committees Hold 51 Business Sessions

In addition to the regular business meetings of the AIEE board of directors, which is reported elsewhere in these pages, business meetings were held by 11 administrative committees and 40 technical committees, subcommittees, or working groups during the winter meeting.

Such news reports of these committee meetings as were made available to *ELECTRICAL ENGINEERING* by or on behalf of the chairmen, are published in the following paragraphs.

REGISTRATION OF ENGINEERS

The AIEE committee on registration of engineers, at its January 28 meeting, was in agreement that the most urgent problem currently before it is the strengthening of the professional status of young engineers whose subprofessional status makes them not yet eligible for state registration. Toward this end, the committee proposed the following resolution to the board of directors, and received supporting action by the board at its January 30 meeting:

Resolved: That the legal registration of Engineer-In-Training Status for recent engineering college graduates, and other equally qualified persons, is beneficial to the public and to the profession. This practice distinguishes men intending to become professional engineers from others not so qualified or so intending. It further is resolved that this resolution be published in *ELECTRICAL ENGINEERING* and that members be urged to assist groups striving to adopt this practice in the states where they reside.

METALLIC RECTIFIERS

The recently issued "Standard Definitions" were discussed at some length, and consideration was given to various written comments which had been received. I. R. Smith (A '43) of East Pittsburgh, Pa., was assigned the task of reviewing these comments and incorporating the best ones in the standards. The test code also was discussed at length, and a committee headed by W. F. Bonner (A '43) of East Newark, N. J., was appointed to review the test code carefully. A representative from the Underwriters Laboratories was invited to co-operate in the review. N. Y. Priessman was assigned the task of organizing a session on metallic rectifiers to be held during the 1948 winter general meeting in Pittsburgh, Pa. The subcommittee decided to hold another business meeting at Worcester, Mass., during the North Eastern District meeting there in April 1947. Secretary Edgar A. Harty (M '36) presided.

AIRCRAFT ELECTRIC MACHINERY

The subcommittee for aircraft electric rotating machinery took note of the fact that the "Test Code for Direct Current Machines" had been approved by the Standards committee, and directed the chairman to make various editorial changes which had been suggested during committee discussion. The factors affecting the rating of engine-driven generators were reviewed and a working group headed by S. M. Potter (A '42) of East Hartford, Conn., was appointed to draft a rating standard for review at the next subcommittee meeting. M. L. Schmidt (M '43) of Fort Wayne, Ind., presided.

SERVOMECHANISMS

The joint subcommittee on servomechanisms held its second formal meeting January 27 during the winter meeting in New York. There it was decided to undertake a study of terminology and definitions, to co-ordinate the activities of the American Standards Association, the AIEE, and the American Society of Mechanical Engineers on this subject. The subcommittee also is co-operating with the basic sciences committee of the New York AIEE Section in the project of publishing papers covering the theory of servomechanisms. Further, a study is being made of the need for a bibliography covering the excellent material on the subject of servomechanisms that has been published to date.

Emphasis was placed especially on the fact that the theory of servomechanisms is applicable to any closed-cycle control system, and hence is of rapidly increasing interest and concern to designers of mechanical, hydraulic, and penumatic control systems. Because of this extensive interest in servomechanisms, the subcommittee plans to augment its membership. Doctor Gordon S. Brown (A '33) of Cambridge, Mass., presided.

LIGHTNING PROTECTION

At the January 28 meeting of the lightning protective devices subcommittee, reports were received from the sponsors of the four working groups, covering:

1. Industry-performance characteristics of expulsion-type distribution arresters.
2. Results from a survey of the lightning protection equipment used on rotating alternating current machines.
3. Lightning protection of unit substations.
4. The combination and revision of AIEE Standards 24, 28, and 47.

A decision was reached also to establish a new project which will have as its objective a report consisting of an application guide for the selection of arrester voltage ratings based upon system operating conditions. W. J. Rudge (M '39) of Pittsfield, Mass., presided.

The working group on the subject of lightning protection of substation units met January 27, and agreed upon a program embracing three points:

1. A limited questionnaire.
2. A series of special tests.
3. An analytical investigation intended to clarify certain aspects of the group's study problem.

E. R. Whitehead (F '45) of Chicago, Ill., presided.

The project group on estimating the lightning performance of transmission lines met January 27 to review the status of its work and to appoint additional sponsors to give particular attention to certain detailed phases of its work. E. R. Whitehead presided as group sponsor.

RELAYS

Approximately 20 subcommittee members and 15 interested visitors attended the January 28 meeting of the relay subcommittee. Progress reports were received and discussed from the following working groups: insulation levels of relay and control circuits, E. L. Michelson (M '44) of Chicago, sponsor; sensitive ground protection, E. T. B. Gross (M '40) of Chicago, Ill., sponsor; electronic relay applications, A. J. McConnell (A '36) of Schenectady, N. Y., sponsor; transmission line protection, E. L. Harder (M '41) of East Pittsburgh, sponsor; (the foregoing four projects are new this year); relay bibliography, C. E. Parks (M '45) of Indianapolis, Ind., sponsor; instrument transformer standards, C. A. Woods, Jr. (M '45) of East Pittsburgh, sponsor; protection of power transformers, W. R. Brownlee (M '38) of Jackson, Mich., sponsor; distribution circuit protection and construction, G. B. Dodds (M '45) of Pittsburgh, Pa., sponsor; (this subject pursued jointly with distribution subcommittee); standards for power relays, S. C. Leyland (M '43) of Newark, N. J., sponsor; grounding of instrument transformer secondaries, the completion of this working project being represented in current technical program paper number 47–65 "Grounding of Instrument Transformer Secondary Circuits," H. R. Paxson (M '40) of Philadelphia, Pa., sponsor. Most of the foregoing topics were the subjects of working group meetings held during the winter meeting in New York.

The relay subcommittee discussed extensively the several aspects of the currently proposed changes in AIEE technical activities and technical-committee organization structure, and forwarded pertinent recommendations through the protective devices committee. The next meeting of the relay subcommittee is planned for some time in May 1947. W. R. Brownlee, chairman, presided.

DIELECTRICS

The working group on revision of transformer dielectric tests met January 30 and initiated three specific investigations, the results of which are required to provide a basis for the critical appraisal and possible revision of the present test specifications:

1. A summary of available data on switching surges.
2. A survey of transformer and apparatus lighting failures as related to the age of the transformer and the type of protection employed.
3. A study of the voltage stresses within the transformer, arising from normal-frequency excitation, switching surges, and impulses.

E. R. Whitehead (F '45) of Chicago, Ill., presided as chairman of the working group.

To discuss plans for the revision of AIEE Standard 4 (ASA *C68.1*) "Measurement of Test Voltage in Dielectric Tests," the special subcommittees on this revision

project met January 29. Inasmuch as the greatest need is the inclusion of measurement methods for surges of less than one microsecond duration, a working group under P. L. Bellaschi (F '40) of Sharon, Pa., was assigned the responsibility of gathering the necessary material. It is expected that this material will come principally from the laboratory studies of a special co-ordinating subcommittee under the chairmanship of J. E. Clem (F '38) of Schenectady, N. Y. The subject of possible new material relating to voltage measurements for direct current and for high frequency alternating currents brought forth considerable discussion. This subject will be carried over for further discussion at the next meeting of the subcommittee, which will be subject to call. J. T. Lusignan (M '34) of Mansfield, Ohio, presided.

COMMUNICATIONS

With 23 members present, the AIEE committee on communication met January 28 to discuss plans for appropriate communications subjects for the meetings programs of the forthcoming summer, Pacific, and Midwest general AIEE meetings. It is contemplated that each of these meetings will include full sessions on radio systems, modulation methods and techniques, underwater sound developments, and hearing aids. In addition, the inclusion of individual papers on various appropriate topics relating to current advances in the art are contemplated. J. J. Pilliod (F '34) of New York, N. Y., presided.

COMMERCIAL WIRING

A new subcommittee on the all-important topic of "interior wiring design for commercial buildings," authorized at the 1946 summer meeting in Detroit, now is functioning under the chairmanship of B. F. Thomas, Jr. (M '29) of New York, N. Y. The subcommittee is sponsored jointly by the AIEE committee on industrial and power applications under the chairmanship of Herbert Speight (M '21) of New York, N. Y., and the AIEE committee on domestic and commercial applications under the chairmanship of C. W. Evans (M '40) of Atlanta, Ga.

The objective of this special subcommittee is to formulate the fundamentals of good practice in the design of electric wiring for commercial buildings, which are defined as being all buildings other than residences and industrial plants. It is expected that the report of this subcommittee may serve as a guide to desired practice, and serve also to call attention to important considerations which all too often are overlooked in the design of wiring systems and in the construction features of commercial buildings, relative to provisions for the proper installation of adequate wiring. Chairman Thomas presided.

SAFETY

The January 29 meeting of the AIEE committee on safety was devoted to discussion of the need for improvement in the methods of treatment for electric shock, particularly as to methods of prompt recognition of heart fibrillation and of methods of restoring normal rhythmic heart action in such cases, a matter of primary importance for successful treatment. Further attention to these matters will result from the discussion, with the object of determining a program for additional research.

The committee expects to continue its attention even more actively to the study of electric hazards on farms, in recognition of the rapid expansion of the use of electric equipment on farms, which makes this subject one of continually increasing importance. Plans were made to sponsor the presentation of papers on the subject of safety at the 1947 summer general meeting in Montreal.

CARBON BRUSHES

The committee on carbon brushes, which is a joint subcommittee of the air transportation committee and the electric machinery committee, held its third meeting January 29. The session was devoted to a discussion of the proposed test code on brushes for electric equipment, which code is being prepared by the committee.

Reports were presented by various members on specific sections of the code, in accordance with subject assignments which had been made at the 1946 summer meeting in Detroit. It is hoped that the code section dealing with the testing of plate stock will be completed in preliminary form at least by midyear. As soon as this section is completed, a group of brush plates will be circulated among the various members of the committee to accommodate actual tests made in accordance with the proposed code specifications. The results of these tests will be analyzed, and any indicated code modifications will be made accordingly.

Appreciable progress has been made on the study of test procedures for determining operating characteristics of brushes, both at sea level and at higher altitudes, but more development in test procedures will be required before the committee will be able to agree on even a preliminary statement of procedures for these tests. This project will be followed up immediately upon the completion of the work concerning plate stock. V. P. Hessler (F '43) of Lawrence, Kans., presided as committee chairman.

ELECTRONIC INSTRUMENTS

The main topic of the January 29 meeting of the joint subcommittee on electronics, was the report on the progress of the current "Survey of Instrument Manufacturers" being made by AIEE for the purpose of determining the need in industry for electronic tubes having special characteristics. To date, questionnaires have been mailed to approximately 400 manufacturers of electronic equipment. Although the questionnaires were sent out only about the first of the year, some 17 per cent of them have been returned with the desired information. Interest is widespread. Government bureaus as well as the armed services have taken an active part in the survey along with the instrument manufacturers.

It is the subcommittee's intention to extend the questionnaire survey to cover manufacturers in Canada and other countries where wide use is made of electronic tubes. Individual members interested in this subject, wherever they may be, hereby are urgently requested by the subcommittee to check with their company officials to determine whether or not a copy of the AIEE questionnaire has been received. It is asked that a request be filed with headquarters for those who have not received a copy yet, and that fulfillment of the questionnaire be expedited in any event for return to headquarters properly filled out. Subcommittee Chairman W. R. Clark (M '44) of Philadelphia, Pa., presided.

INSULATION RESISTANCE

The insulation resistance subcommittee of the electric machinery committee spent most of its January 28 meeting discussing the minimum insulation resistance limits that should be established for d-c machines. Considerable progress in this discussion was made, and the committee hopes that the work can be completed during 1947.

The subcommittee recently completed its "Report on Recommended Practice For Insulation Resistance Testing of A-C Rotating Machinery," which has been published as "AIEE Standards Report Number 43." This publication is available from AIEE headquarters for the general use of industry, and the subcommittee especially desires to receive comment and criticism concerning the report from all those who may use it or be interested in it.

The subcommittee recommendations on temperature limits for silicone insulating materials, as well as a definition and class designation for those materials, was submitted to the AIEE Standards committee during 1946. These recommendations now are under consideration by the Standards committee relative to its impending revision of AIEE Standard 1.

BASIC SCIENCES

At a meeting of the committee on basic sciences January 28 a review was made of the activities of the subcommittees on applied mathematics, new energy sources, and large-scale computing devices.

It was believed that efforts should be made to continue the co-operation between the American Mathematical Society and the subcommittee on applied mathematics, by bringing specific engineering problems to the attention of the mathematicians for solution, rather than considering only general problems which might be discussed from an abstract viewpoint. Because the AMS usually has summer meetings, it was thought more appropriate to omit a mathematics conference from the Institute summer general meeting, and concentrate on efforts for the Midwest (October) general meeting, or 1948 winter general meeting. Professor M. G. Malti (M '45) of Ithaca, N. Y., is chairman of this subcommittee.

The subcommittee on new energy sources under the chairmanship of Doctor W. A. Lewis (F '45) of Chicago, Ill., has been very active, and, although a conference on this subject is not planned for the summer general meeting, plans already are being made for the October meeting. The first

of a series of conferences was held January 29 covering a survey of the field including emission, piezoelectric, and electrostatic phenomena. Future conferences will consider the subjects of thermoelectricity, electrochemistry, magnetostriction, and so forth and several conferences will be held.

Large-scale computing devices appear to have a growing interest, and the subcommittee under C. Concordia (M '37) of Schenectady, N. Y., plans to continue conferences at future technical meetings, similar to the conference held January 30 at the winter meeting.

Professor J. G. Brainerd's subcommittee on electric circuit theory is just getting under way. One of the first tasks of this group is concerned with definitions in this branch of electrical engineering, a problem quite appropriate at this time, because the ASA Committee *C42*, Definitions of Electrical Terms, now is being revived after the interruption caused by World War II. Close co-operation between committee *C42* and the committee on basic sciences is expected, for the chairman of the latter committee is also chairman of subcommittee number 1, fundamental and derived terms, of *C42*.

With some technical activites of the committee on basic sciences well established in the hands of the afore-mentioned four subcommittees, thought is being given to setting up additional subcommittees to insure that all fields within the scope of this committee are properly covered. Suggestions of additional subcommittees are requested from the membership. Chairman J. D. Tebo (M '36) of New York, N. Y., presided.

ELECTRONICS

A meeting of the AIEE committee on electronics was held at Institute headquarters January 30, Chairman W. R. G. Baker (M '41) of Syracuse, N. Y., presiding. A feature of this meeting was a discussion by L. W. Chubb (F '21), current recipient of the 1946 John Fritz Medal (of East Pittsburgh, Pa.) concerning proposed plans for an AIEE technical committee to cover the very important and rapidly growing field of "nucleonics," and a review of ways and means of co-ordinating the work of the electronics committee with the new proposed nucleonics program.

The currently active program of the electronics committee includes the following specific activities:

1. Continued emphasis on standardization, particularly in relation to electronic power-conversion equipment and to electron tubes.

2. Active and specific support, in whichever ways may seem desirable, of attention currently being given within the AIEE organization to applications of electronic technique and devices. This may take the form of participation in joint subcommittees, liaison representation on other committees, or others. This project relates to electronic instrumentation, electronic control, electronic welding, electronic heating, and other such matters.

3. Insuring adequate coverage, by means of technical sessions and through *ELECTRICAL ENGINEERING*, of the basic new electronic developments, including active assistance in the obtaining of such coverage in applicational fields.

4. Familiarizing the various AIEE local Sections with the availability and the sources of motion picture films, qualified speakers, interesting demonstrations, and other such material that can be used to advantage by the Sections in contributing to the broadening of the education of Section members in this rapidly developing field.

5. Continued efforts to establish firm technical co-ordination between the electronic heating industry and the communication industry, especially as to frequency allocation and related problems.

AIEE MEMBERSHIP

An all-time high record of 26,728 AIEE members was announced by the AIEE national membership committee at its January 28 meeting. This total represents a 1946 net increase of some 2,366 members. Notwithstanding this phenomenal growth, the membership committee laid definite plans for the further development of AIEE membership. With virtually all of the ten AIEE Districts represented at the meeting by the District vice-chairmen of the national committee, there was opportunity for discussion and review of the membership-activity procedures as followed in different sections of the country, and opportunity to co-ordinate the basic national plan with the various situations in the different Districts.

The national membership committee is convinced that the greatest reservoir of potential new AIEE members is represented in the graduating classes of electrical engineering schools. A plan has been developed, whereby talks covering the advantages of AIEE membership will be made before all new electrical engineering students, to urge them to join the local Student Branches. Professor J. F. Calvert (F '45) of Evanston, Ill., chairman of the AIEE committee on Student Branches, attended the meeting and counseled the committee members concerning details of working out this co-operative plan with local Student Branches. A decision was reached to form a joint subcommittee of the membership and the Student Branch committees for the purpose of developing a joint plan for stimulating interest among new college graduates in the possibilities of AIEE membership. This subcommittee will endeavor to increase the number of transferees from Student membership to Associate membership, also. Representing the membership committee on this joint subcommittee are: R. F. Ham (A '36) of New York, N. Y. (chairman); F. S. Bacon, Jr. (M '44) of Boston, Mass.; and R. C. Horn (M '44) of St. Louis, Mo.; to represent the Student Branches committee. Professor Calvert is to appoint three additional members to this subcommittee.

For the purpose of reviewing and bringing up to date the "Section Membership Committee Manual," there is a special subcommittee consisting of F. S. Black (M '44) of Washington, D. C., and J. C. Woods (M '31) of Chicago, Ill. Every effort will be made to have this revision completed and ready for the new membership committees which will be appointed for the 1947–48 year. The booklet, "Accomplishments of the AIEE in the Engineering World," has been brought up to date for early publication. With these additional tools, it is hoped that membership activity in every District will be more effective.

Discussion at the January 28 meeting brought out clearly the fact that the effectiveness of membership committee activity nationally is directly dependent upon the chairmen of the individual local Section membership committees. The excellent job currently being done on membership development in all Districts is almost entirely creditable to the effectiveness of these local Section officers. To encourage continuance of this good work, the national membership committee instructed its chairman to write a letter to the AIEE vice-president in each District appropriately complimenting the work of Section membership committee chairmen in the District. The vice-presidents also will be urged to take advantage of every opportunity to impress upon chairmen of local Sections the importance of membership work and the necessity for discriminating care in selecting personnel for appointment as local Section chairmen of membership committees.

Official Nominees Announced for 1947–48

B. D. Hull, chief engineer, Southwestern Bell Telephone Company, St. Louis, Mo., was nominated for the AIEE presidency for the year 1947–48 at the meeting of the nominating committee in New York, N. Y., January 29. Others named on the official ticket of candidates for the Institute offices that will become vacant August 1, 1947, are:

For Vice-Presidents

G. W. Bower, Public Service Electric and Gas Company, Newark, N. J. (Middle Eastern District, number 2).

J. H. Berry, manager, Norfolk district, electric department, Virginia Electric and Power Company (Southern District, number 4).

I. M. Ellestad, transmission engineer, chief engineer's department, Northwestern Bell Telephone Company, Omaha, Nebr. (North Central District, number 6).

D. I. Cone, transmission and protection engineer, Pacific Telephone and Telegraph Company, San Francisco, Calif. (Pacific District, number 8).

D. G. Geiger, transmission engineer, general engineering department, Bell Telephone Company of Canada, Toronto, Ontario (Canada District, number 10).

For Directors

A. C. Monteith, manager, industry engineering department, Westinghouse Electric Corporation, East Pittsburgh, Pa.

W. L. Everitt, professor and head of the electrical engineering department, University of Illinois, Urbana.

E. B. Robertson, president, Plastics Manufacturing Company, Dallas, Tex.

For Treasurer

W. I. Slichter, professor emeritus, electrical engineering, Columbia University, New York, N. Y.

The nominating committee, in accordance with the constitution and bylaws, consists of 15 members, one selected by the executive committee of each of the ten geographical Districts, and five selected by the board of directors from its own membership.

The constitution and bylaws of the Institute require publication in *ELECTRICAL ENGINEERING* of the nominations made by the nominating committee. Provision is made for independent nominations as

indicated in the following excerpts from the constitution and bylaws:

Constitution

Section 31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the secretary when and as provided in the bylaws; such petitions for the nomination of vice-presidents shall be signed only by members within the District covered.

Bylaws

Section 23. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with article VI, section 31 (Constitution), must be received by the secretary of the nominating committee not later than March 25 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the nominating committee in accordance with article VI of the Constitution and sent by the secretary to all qualified voters during the first week in April of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

BIOGRAPHICAL SKETCHES OF NOMINEES

To enable those Institute members not acquainted personally with the nominees to learn something about their engineering careers and their qualifications for the Institute offices to which they have been nominated, brief biographical sketches are scheduled for inclusion in the "Personal" columns of the April issue.

J. B. MacNeill Chosen for 1946 Lamme Medal

The award of the AIEE Lamme Medal for 1946 has been made to J. B. MacNeill (F'42) manager of the switchgear and control division, Westinghouse Electric Corporation, East Pittsburgh, Pa., for "his foresight, leadership, and creative contribution in the development of switching equipment."

Awarded annually to an engineer "who has shown meritorious achievement in the development of electric apparatus or machinery," the AIEE Lamme Medal was established through a bequest of the late Benjamin G. Lamme, chief engineer of the Westinghouse Electric Corporation. Disposal of the medal is decided by an AIEE committee organized for the purpose. The first award was made in 1928.

A biographical sketch of Mr. MacNeill will appear in the April 1947 issue of *ELECTRICAL ENGINEERING*.

AIEE Subcommittee Briefs FCC on Radio Interference

Results of a study of engineering specifications involved in establishing regulations on allowable radio interference from high-frequency heating apparatus were presented to a hearing of the Federal Communications Commission in Washington, D. C., December 17, 1946, by the AIEE electronic heating subcommittee.

Compilation of data on radio interference has been one of the major activities of this subcommittee of the electronics committee, which is composed of manufacturers and users of induction and dielectric heating apparatus. Results of the study will be published in a report by Committee Secretary W. C. Rudd (A'34) chief engineer, Induction Heating Corporation, New York, N. Y. This report is scheduled to appear in a forthcoming issue of *ELECTRICAL ENGINEERING*.

Welding Bibliography Completed by AIEE Committee

A bibliography on "Power Supply for Resistance Welding" now is being prepared for publication by the AIEE committee on electric welding.

Covering the years from 1942 to 1946, the subject matter has been screened carefully. A rather unique index has been prepared for ready reference, so that investigators will not have to look through too much material for their needs.

Inquiries about this bibliography should be addressed to AIEE headquarters, 33 West 39th Street, New York 18, N. Y.

Committee Appointed for 1947 Pacific General Meeting

Announcement of the membership of the general committee to make plans for the annual AIEE Pacific general meeting to be held in San Diego, Calif., August 25–29, 1947, has been made by President J. E. Housley.

Members of the committee are:

J. F. Sinnott, *chairman;* B. B. Gravitt, *vice-chairman;* W. J. Kenline, *secretary;* R. T. Strong, *treasurer;* W. M. Allen; F. J. Bartholomew; I. W. Best; D. I. Cone; A. V. Eastman; F. F. Evenson; J. R. Jarvis; C. F. McCabe; E. W. Morris; D. H. Olney; W. L. Smith; C. F. Terrell; Abe Tilles; W. J. Warren; and E. W. Williams.

DISTRICT • • • • •

Preliminary Meeting Plans of North Eastern District

Preparations are almost completed for the North Eastern District meeting and Student Branch convention to be held in Worcester, Mass., on April 23, 24, and 25, 1947. Meeting headquarters will be the Hotel Sheraton, and all technical and social gatherings will be held in their recently redecorated rooms.

The dominant theme of the meeting is to be "applications engineering," and nine technical sessions will deal with this major point of view in the fields of: electric drives for machine tools; servomechanisms; communications; carrier currents; electronic devices; power transmission; cable developments; transportation; and electric heating.

Worcester offers excellent opportunities for inspection trips supplementing the material of the technical sessions. Tentatively scheduled for inspection are plants of the American Steel and Wire Company, the Norton Company, the Heald Machine Company, and the central dispatching station of the New England Power System.

The general session of the meeting on Thursday morning will feature an outstanding address on a subject of general interest plus ample opportunity for discussion of Institute activities of vital interest to all members.

The Student Branch convention on Friday morning is expected to bring out a record attendance, as Worcester is centrally located among the 18 colleges and universities of the District. The host Branch at Worcester Polytechnic Institute is making extensive plans to insure its success.

One of the high points of the program for women will be a luncheon at the Wayside Inn in Sudbury, immortalized by Longfellow, and now restored and operated by Henry Ford.

The evenings will be devoted to the social activities with a smoker and entertainment on Wednesday evening and an informal banquet on Thursday evening.

Arrangements are under the general chairmanship of T. H. Morgan (F'39) with Victor Siegfried (M'38) chairman of the local technical program committee.

Pacific District Executive Committee Meets

A plan for rotating the candidates for the AIEE vice-presidency among the Sections of the District was approved at the meeting of the executive committee of the Pacific District held in November 1946. Locations for District and general meetings also were approved, and Section, membership, and Branch activities were discussed.

The following sequence of rotation, which is to function as a guide in the selection of vice-presidential candidates and nominating committee delegates, was approved:

Vice-President		National Nominating Committee Delegate	
1949	Los Angeles	1948	Los Angeles
1951	Arizona	1949	San Diego
1953	San Francisco	1950	San Francisco
1955	Los Angeles	1951	Los Angeles
1957	San Diego	1952	Arizona
1959	San Francisco	1953	San Francisco

The committee also agreed to review the matter yearly.

For future meetings, the committee approved San Francisco as the location for the Pacific general meeting to be held in the summer of 1949 and Los Angeles as the location of a proposed combined AIEE summer general meeting and Pacific general meeting in 1950. The Arizona Section asked to be considered as host for the Pacific general meeting in 1952.

MEMBERSHIP ACTIVITIES

In the matter of membership activities, it was revealed that the Los Angeles Section is placing particular emphasis on

developing a program which will be of interest to the industrial electrical engineers. For this purpose a committee has been formed, consisting of the chairman of the membership committee, two representatives from electrical manufacturers, and one representative each from the two larger utilities. Present indications are that approximately 200 such prospective members are in the Los Angeles area.

The Arizona Section reported as its goal a total of 100 national members in the Section for the year. Though the Section is continuing its local membership, its efforts will be concentrated on securing national members, and only prospective national members will be encouraged to become local members.

SECTION ACTIVITIES

With reference to Subsection activities, the consensus of the executive committee was that the prefix "sub" is unfortunate. The committee, therefore, recommended to the AIEE Sections committee that the designation "chapter" or "division" be substituted for Subsection.

The Los Angeles Section reported that it is supporting actively the establishment of a joint employment service for engineers by the local Engineering Council. The Section is represented on the council by four members.

Monthly dinner meetings are held from September through May, according to the report of the Arizona Section. The first meeting of the year was held at Prescott, and it is planned to hold the final meeting at Tucson, as a joint meeting with the Student Branch of the University of Arizona. Other meetings are being held in Phoenix. Almost one third of the Section membership is serving on one committee or another, and the Section has appointed an advisory committee to work with other engineering organizations toward the formation of an Arizona Engineering Council.

The San Francisco Section reported that it holds one dinner meeting, as well as two or three technical meetings each month. The technical meetings cover electronics and communication, power, or industrial fields, and a meeting on basic science frequently is alternated with one of the other subjects. One technical meeting is held in Oakland each month.

The San Diego Section currently is considering the formation of a Subsection in the Imperial Valley, it was stated.

All Branches reported phenomenal memberships, composed in general of returned veterans. The Student Branch at Stanford University is working jointly with the Institute of Radio Engineers as a communication or electronics group. The Branch at the California Institute of Technology is considering the formation of an engineering society to replace the different branches of the Founder Societies. Formation of a Student Branch at San Diego State College was discussed, though that institution does not confer engineering degrees.

REGISTRATION OF ENGINEERS

The draft of the prospsosed Registration Act for Professional Engineers, submitted to the California Legislature in January 1947, was presented to the executive committee. The proposed act is the joint work of the Engineering Councils of Los Angeles and San Francisco. It was the opinion of the committee that the proposed act is necessary: first, to define professional engineering; second, to improve the status of professional engineers; and third, to provide the same policing of the entire professional engineering field that now is restricted to civil and structural engineering. An additional factor was the belief that the act would afford protection to the professional engineer under the Wagner Labor Relations Act.

Present at the meeting were:

District

F. F. Evenson, vice-president; E. W. Morris, vice-chairman, AIEE membership committee; W. J. Warren, chairman, District committee on student activities.

Arizona Section

I. W. Best, chairman; F. J. Groat, secretary.

Los Angeles Section

E. W. Morris, chairman; H. D. Strong, vice-chairman; Bradley Cozzens, secretary.

San Diego Section

G. F. McCabe, chairman; G. E. Jenner, vice-chairman; H. A. Cordes, secretary.

San Francisco Section

Abe Tilles, chairman; H. E. Becker, vice-chairman; J. L. Buckley, secretary.

SECTION ● ● ● ● ●

Subsection Honors Edison. A centennial program honoring the birth of Thomas A. Edison was arranged by the AIEE Fort Worth Subsection for February 11. A lecture and a lighting demonstration were held in the auditorium of the city's public library with F. J. Graham of the General Electric Company as the speaker for the evening.

PERSONAL ● ● ● ●

W. C. Kochendoerffer (M'38) division engineer, outside plant bureau, Consolidated Edison Company of New York (N. Y.), Inc., has retired. Born in New York in 1881, he received the degree of bachelor of science from Cooper Union in 1906 and the degree of civil engineer from the Polytechnic Institute of Brooklyn in 1910. He was associated with the Public Service Commission, New York, from 1906 to 1916, during the planning and construction of the rapid transit subway, as draftsman, assistant engineer, and section engineer. He served with the Corps of Engineers in the United States and France from 1917 to 1919. He had been with the Edison System since 1922, serving until 1928 as assistant to the engineer of the distribution and installation department of the New York Edison Company, and from 1929 to 1936 as division engineer with the New York and Queens Electric Light and Power Company. After the consolidation of the system in 1936, he became division engineer in the outside plant bureau. He is a member of the National Society of Professional Engineers.

R. W. Larson (M '44) formerly assistant to the chief engineer, Radio Corporation of America, Lancaster, Pa., has been appointed administrative assistant to the director of the research laboratory of the General Electric Company, Schenectady, N. Y. Mr. Larson first joined the General Electric Company in 1922, the year he was graduated from Rensselaer Polytechnic Institute. In 1930 he was one of a group which formed the nucleus of the vacuum tube engineering department. When this became the tube division of the electronics department, Mr. Larson was named assistant engineer. He left the company in 1943 to become technical aide and deputy chief of division 15, of the National Defense Research Committee. He became consultant for the division, when he joined the Radio Corporation of America in 1944.

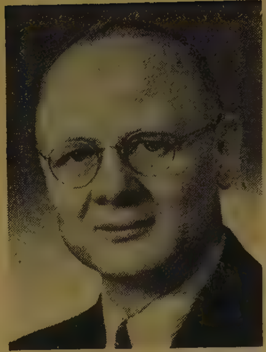
G. R. Milne (A '21, M '30) formerly assistant manager of system operation, Consolidated Edison Company of New York (N. Y.), Inc., has been appointed manager of the system operation department. A graduate of Stevens Institute of Technology, Mr. Milne joined the Consolidated Edison System in 1921. Since he was assigned to the company's executive development program in 1943, he has been assistant purchasing agent, engineer in charge of steam operation for the New York Steam Corporation, and superintendent of the company's East River station.

A. K. Joecks (A '41) formerly division engineer, test bureau, electrical engineering department, Consolidated Edison Company of New York (N. Y.), Inc., is now assistant test engineer. **F. L. Williams** (A '29) formerly assistant division engineer, and **Otto Stamm** (A '20, M '27) formerly assistant engineer, field test division, technical service department, have been made division engineers. **G. G. Adams** (A '25) formerly junior engineer, is now test supervisor.

W. F. Taylor (M '37) formerly manager of the Allis-Chalmers Manufacturing Company district office, Boston, Mass., has been made regional manager for the New England area. **D. S. Kerr** (A '41) formerly manager of the company's district office in Atlanta, Ga., has been named regional manager for the Southeast area. **J. L. Pratt** (A '38) formerly manager of the district office in Dallas, Tex., is now regional manager for the Southwest.

William Kelly (F '25) president, Buffalo (N. Y.) Niagara Electric Corporation, has been nominated as president of the Society of Military Engineers.

H. E. Deardorff



F. H. Pumphrey

Pach Brothers

C. M. Slack

F. H. Pumphrey (M'25) formerly engineer of the educational division of the General Electric Company, Schenectady, N. Y., has been appointed head of the electrical engineering department of the University of Florida, Gainesville. In his new position Professor Pumphrey not only will administer the instructional program of the department but also will supervise the electrical engineering portion of the university's engineering and industrial experiment station work. Professor Pumphrey was graduated from Ohio State University in 1921 and spent several years with electrical utility companies: the Dayton (Ohio) Power and Light Company, the Kansas Gas and Electric Company, Wichita, and the Staten Island (N. Y.) Edison Corporation. In 1928, following a short period as instructor at Iowa State University, Ames, he was appointed head of the electrical engineering department at Rutgers University, New Brunswick, N. J., where he remained until 1942. During World War II, he served, with the rank of lieutenant colonel, as chief of the Curricula Analysis and Co-ordination Branch of the Military Training Division, Office of the Chief Signal Officer, Washington, D. C. When the Army Specialized Training Program was organized, he was transferred to the headquarters of the Army Service Forces and placed in charge of technical curricula. After his discharge from service in 1945, he joined the General Electric Company. Professor Pumphrey has served on the AIEE committees on communication and publication. He is a member of the Institute of Radio Engineers, the American Society for Engineering Education, Tau Beta Pi, Eta Kappa Nu, Sigma Xi, and Phi Beta Kappa.

M. R. Sullivan (M'42) formerly president of the Chesapeake and Potomac Telephone Company, Washington, D. C., has been elected president of the Pacific Telephone and Telegraph Company, San Francisco, Calif. Mr. Sullivan was born in 1894 in Oakland, Calif., and commenced his career in the Bell System as a clerk for the Pacific Company in 1913. In 1929 he became traffic manager of the Northern California and Nevada area of the company; in 1934 he was appointed vice-president and general manager of the area; and in 1939 vice-president and general manager of the company. He was transferred to New York, N. Y., as vice-president of the American Telephone and Telegraph Company in 1941, and to Washington, D. C., as president of the Chesapeake Company in 1945.

H. E. Deardorff (A '37, M '45) supervisor of system planning engineering, Dayton (Ohio) Power and Light Company, also has been appointed a vice-president of the company. Mr. Deardorff joined the company in 1922, when he was graduated from the University of Cincinnati. He has been supervisor of the electrical maintenance department, substation design engineer, and engineer in the electric meter and test department. In 1940 he was made supervisor of system planning engineering. He is a member of the electric equipment committee of the Edison Electric Institute.

C. M. Slack (M '43) formerly assistant director of research, lamp division, Westinghouse Electric Corporation, Bloomfield, N. J., has been chosen to succeed **H. C. Rentschler** (M '40) as director of research. Doctor Rentschler who is approaching retirement, will devote himself to completing certain research projects in addition to serving in an advisory and consulting capacity. Doctor Slack holds the degrees of bachelor of science (1922) from the University of Georgia, and master of science (1923) and doctor of philosophy (1926) from Columbia University. After a year as instructor in physics at Columbia University, New York, N. Y., Doctor Slack joined the Westinghouse lamp division in 1927. He became assistant director of research in 1943.

Anthony Pinto (A '11, M '18) of the engineering department of the Otis Elevator Company, New York, N. Y., has been appointed chief engineer of the company. Born in Italy in 1883, Mr. Pinto holds the degree of bachelor of engineering (1907) from Cooper Union and the degree of electrical engineer from Columbia University (1916). He was assistant professor at Cooper Union, New York, from 1913 to 1919, and in 1920 became assistant to the chief engineer of the New York Edison Company. In 1922 he joined the Otis Company as test engineer and in 1924 was made assistant chief engineer.

T. F. McMains (A '34, M '44) division traffic superintendent, Western Union Telegraph Company, New York, N. Y., has been appointed assistant vice-president of the Western Union traffic department. Mr. McMains received the degree of bachelor of science from the University of Illinois in 1927 and entered the employ of the Western Union Company as an engineering apprentice. He became an engineering assistant and general inspector in the traffic department headquarters in New York in 1935 and was appointed traffic superintendent of the metropolitan division in 1941.

C. H. Stout (A '42) of Little Rock, Ark., recently returned from service in the South Pacific with the United States Merchant Marine, has been appointed sales representative for the Weston Electrical Instrument Corporation, Newark, N. J., for the territory consisting of Arkansas, western Tennessee, northern Mississippi, and northern Louisiana. Mr. Stout is a graduate of the University of Illinois.

J. R. Shoffner (A '29, M '37) has resigned as chief engineer of the Allegheny River Mining Company and as chief engineer of the Freebrook Corporation but will continue to operate his consulting engineering firm in Kittanning, Pa. **J. M. Shoffnre**

C. H. Stout

Anthony Pinto

T. F. McMains

(A '43) who recently completed three years of service as a lieutenant in the United States Navy, now is associated with J. R. Shoffner. He is a graduate of Carnegie Institute of Technology and the Harvard School of Business Administration.

J. F. Getz (A '43) formerly manager of switchgear sales, I-T-E Circuit Breaker Company, Philadelphia, Pa., has been appointed assistant to the president of the company. A 1935 graduate of Pennsylvania State College, Mr. Getz previously was associated with the General Electric Company and the Roller-Smith Company, Bethlehem, Pa. He joined the I-T-E company in 1944 as manager of the Washington, D. C., office and was made manager of switchgear sales in 1945.

L. G. Pacent (M '18, F '30) president and technical director, Pacent Engineering Corporation, New York, N. Y., has received the War Department Certificate of Appreciation for "valuable assistance to the Signal Corps by developing and adopting manufacturing techniques which involved mass production of communication equipment, and the fact that these laboratories (Signal Corps) were able to accomplish vital phases of their mission to provide many types of advanced designs of new equipment for our fighting forces was in large measure due to your important contributions."

E. L. Hubbard (A '41) formerly sales engineer, General Electric Company, Detroit, Mich., has been made sales manager of the metallurgy division of the company's chemical department, Pittsfield, Mass. Mr. Hubbard has been with the company since he was graduated from Michigan State College in 1925. He has been employed variously in the small motor department, Lynn, Mass., and the Philadelphia, Pa., sales office. He was transferred to the Detroit office in 1938.

R. F. Cline (A '37, M '44) formerly research engineer, Norton Abrasives, Chippawa, Ontario, Canada, has been made chief research and development engineer for the Thermac Company, Los Angeles, Calif. After his graduation from the University of Toronto in 1936, Mr. Cline was associated with the Norton Company until 1945. He resigned to continue his studies at the California Institute of Technology from which he received the degree of master of science in electrical engineering in 1946.

T. H. Soren (A '01) vice-president of the Hartford Electric Light and Connecticut Power Companies, has retired. Mr. Soren will continue as director of both companies and has been retained as consulting engineer. An 1893 graduate of Harvard University, Mr. Soren was associated with the General Electric Company in Schenectady, N. Y., New York, N. Y., and Atlanta, Ga., from 1895 to 1916. He joined the Hartford Company in 1916 and under his direction the pioneer commercial applications of the mercury vapor process were made at the Dutch Point and South Meadow stations.

H. L. Buck (A '35) formerly assistant general manager in charge of special products, I-T-E Circuit Breaker Company, Philadelphia, Pa., has been elected treasurer of the company. Mr. Buck, a 1934 graduate of Drexel Institute of Technology, joined the sales department of the I-T-E Company in 1935 and was appointed assistant to the president in 1944. He was made assistant general manager in 1945.

W. B. Morton (A '25, F '42) station electrical engineer, Pennsylvania Power and Light Company, Allentown, has been awarded the Medal of Services of War by Brazil for his contribution to the construction of Brazilian naval vessels in his assignment as material superintendent at the Philadelphia (Pa.) Navy Yard during the war. Mr. Morton holds the rank of commander in the United States Naval Reserve and is a past director of AIEE.

O. E. Buckley (M '19, F '29) president, Bell Telephone Laboratories, Inc., New York, N. Y., recently received the annual medal of the Telephone Broadcasters Association "for his supervision of the application to television to military uses during the recent war and his work in the application of his broad communication knowledge of the transmission of television programs."

H. C. Dean (A '12, F '30) executive vice-president, Consolidated Edison Company of New York (N. Y.), Inc., has been appointed a member of the Board of Education of the City of New York.

OBITUARY ....

Walter Sheldon Rodman (A '07, M '12, F '28) dean of engineering and professor of electrical engineering, University of Virginia, Charlottesville, Va., died December 31, 1946. Born September 1, 1883, in Wakefield, R. I., Dean Rodman received from Rhode Island State College the degrees of bachelor of science in 1904 and master of science in 1907 and from Massachusetts Institute of Technology the degree of master of science in 1909. He commenced his teaching career as instructor at Rhode Island State College, Kingston, from 1904 to 1908. Joining the faculty of the University of Virginia in 1910 as professor of electrical engineering in charge of the department, he was named acting dean of engineering in 1931 and dean of engineering in 1933. He was an associate member of the Naval Construction Board and, during the first World War, was its director for Virginia. He was a past chairman of the AIEE Virginia Section and had served on the AIEE committees on Student Branches, Sections, electrophysics, education, Edison Medal, and Members-for-Life Fund. He had represented the AIEE on the American Engineering Council and on the engineering research committee of the Engineering Foundation. He was a member of the Illuminating Engineering Society, the American Association of University Professors, the American Society for Engineering Education, the American Association for the Advancement of Science, Phi Beta Kappa, Tau Beta Pi, and Sigma Xi.

Frank Clifford Stockwell (A '12, M '27) Anson Wood Burchard Professor of electrical engineering and chairman of the department of electrical engineering, Stevens Institute of Technology, Hoboken, N. J., died December 29, 1946. Professor Stockwell, who was born in Warwick, Mass., April 22, 1883, received the degree of bachelor of arts from Bates College in 1905 and the degree of bachelor of science in 1907 from Massachusetts Institute of Technology. He immediately was appointed instructor of physics at Stevens Institute of Technology and in 1910 became an instructor in the electrical engineering department. He was appointed assistant professor in 1917, associate professor in 1921, and professor and chairman of the department in 1925. In 1930 he was appointed Anson Wood Burchard Professor, and from 1939 to 1944 he served as dean of the graduate school. Professor Stockwell also was chief instructor in laboratory practices courses for the New York Edison Company from 1913 to 1925 and educational director from 1925 to 1932. Professor Stockwell practiced as a consulting engineer and in that capacity was associated with the Empire Electric Brake Company, Newark, N. J. He was an expert in patent litigation and was the author of a "Laboratory Practice Manual." Professor Stockwell received the honorary degree of doctor of engineering from Stevens Institute of Technology in 1945. He was a member of the Institute of Radio Engineers, the American Society for Engineering Education, Tau Beta Pi, and Phi Beta Kappa.

George Thompson Southgate (A '11, M '39) chief engineer, Vanadium Corporation of America, Bridgeville, Pa., died November 8, 1946. Born in Nashville, Tenn., June 26, 1886, Mr. Southgate received the degree of bachelor of science in electrical engineering from Massachusetts Institute of Technology in 1910. He was assistant to the resident engineer of Ford, Bacon and Davis, engineers for the Houston (Tex.) Lighting and Power Company, from 1910 to 1913. In 1913 he joined the Electric Bond and Share Company, New York, N. Y., as assistant to the chief electrical engineer. He became first assistant electrical engineer for the Air Nitrates Corporation, New York, in 1918 and, after the war, was transferred to the parent company, the American Cyanamid Company, as research engineer. He was consulting engineer to

the Federal Phosphorus Company, Birmingham, Ala., in 1922 and 1923 and afterwards developed the Pyrelectric process of joint fuel-electric furnacing. He was consulting engineer for the Grasselli Chemical Company, Cleveland, Ohio, from 1924 to 1926 and for the Electro Metallurgical Company, New York and Niagara Falls, N. Y., in 1927 and 1928. From 1929 to 1934 he was research engineer at the Union Carbide and Carbon Research Laboratories, Inc., Long Island City, N. Y. He returned to his private consulting practice in 1934 and in 1943 was appointed chief engineer of The Vanadium Corporation. He was a member of the Electrochemical Society.

Frank Charles Czarnecki (A '15) engineer, Smith, Hinchman and Grylls, Consulting Engineers, New York, N. Y., died December 25, 1946. Mr. Czarnecki was born December 25, 1889, in San Francisco, Calif., and was graduated in 1912 from the University of California at Berkeley. He was secretary to the president of the Great Western Power Company of California, San Francisco, from 1913 to 1917. After a year as superintendent of the United States Government helium gas plants, Fort Worth, Tex., he became engineer with the Atlantic Gulf Oil Corporation, New York, in 1919. Afterwards he was associated with the Public Service Electric Company, Newark, N. J. In 1927 he joined Barker and Wheeler, Consulting Engineers, New York, and in 1928 Brown Brothers and Company, New York. He helped prepare the report on marketing and distribution on the St. Lawrence River which resulted in the establishment of the St. Lawrence Power Development Commission. In 1933 and 1934 he devoted his energies to the Professional Engineers Committee on Unemployment, which he helped organize. From 1935 to 1943 he was associated with the General Cable Corporation, New York, and in 1944 joined Smith, Hinchman and Grylls.

Frederick William Schneider (A '17) retired instructor of electricity, Murray Hill Industrial High School, New York, N. Y., died December 28, 1946. Born in Cincinnati, Ohio, September 3, 1875, Mr. Schneider was graduated from Rose Polytechnic Institute in 1898. At the start of his career, he was associated with the Wabash Railroad, Moberly, Mo., and with the Cumberland Telephone and Telegraph Company, Nashville, Tenn. In 1900 he joined the General Electric Company, Schenectady, N. Y., as foreman of tests for the Government. He became supervising engineer for the company on board the Imperial Russian cruiser, *Variag*, during its construction. Later Mr. Schneider delivered the vessel to Vladivostok, Russia, and, at the insistence of the Russian Government, renounced his American citizenship for the duration of the voyage and became a Russian citizen. After leaving the General Electric Company in 1903, he became electrical expert for the Tucker Electric Construction Company, New York, and an inspector for the Department of Water Supply Gas and Electricity of the City of New York. In 1910 he was made assistant to the chief inspector. He became an instructor in electricity in the Murray Hill School in 1919, and he retired in 1945.

Elmer Ellsworth Browning, Jr. (M '38) plant extension engineer, American Telephone and Telegraph Company, New York, N. Y., died January 8, 1947. He was born September 12, 1888, in Baltimore, Md., and was graduated from the University of Wisconsin with the degree of bachelor of science in 1921. Immediately afterwards he became an apprentice in the long lines department of the American Telephone Company. Later he was assistant traffic chief in Chicago, Ill., and, during the first World War, he was assigned to Washington, D. C. In 1918 and 1919 he had charge of traffic facilities in Philadelphia, Pa., and then joined the operation and engineering department in New York. He was appointed supervisor of toll traffic for the New England Telephone and Telegraph Company in 1923 and engineer of toll methods for the parent company in New York in 1925. In 1934 he was made assistant to the chief engineer and vice-president and, since 1937, had been plant extension engineer. Mr. Browning was a member of Eta Kappa Nu.

Karl Johann Jakob Stiefel (A '39) executive engineer in charge of electronic control equipment, Photoswitch, Inc., Boston, Mass., died October 28, 1946. Doctor Stiefel was born October 5, 1905, in Zurich, Switzerland, and received his diploma in engineering from the Swiss Federal Institute of Technology in 1930. He studied at the Massachusetts Institute of Technology from 1934 to 1936 on an exchange fellowship, and in 1939 received his doctor's degree from the University of Zurich. He was instructor at the Swiss Federal Institute of Technology, Zurich, in 1933 and 1934 and at Worcester (Mass.) Polytechnic Institute in 1938. During the war, Doctor Stiefel was research engineer with the Raytheon Manufacturing Company, Waltham, Mass., and in 1946 joined Photoswitch, Inc. He was a member of the Institute of Radio Engineers, the American Society for Engineering Education, and Sigma Xi.

Hoyt D. Griffith (A '45) manager of the Springfield (Mass.) district of the Westinghouse Electric Corporation, died January 4, 1947. Mr. Griffith was born October 25, 1886, in Hillsboro, Ohio, and attended Carnegie Institute of Technology. He joined the Westinghouse Company in East Pittsburgh, Pa., in 1909, as manager of the diagram section of the switchboard department. After serving in the switchboard engineering department and the switchboard sales department, he was transferred to Buffalo, N. Y., in 1918. He went to the sales department of the Providence, R. I., office in 1921 and to the Springfield office in 1931. He was made manager of the Springfield office in 1935. Previously he had been an Associate of the AIEE from 1937 to 1944.

MEMBERSHIP

Recommended for Transfer

The board of examiners, at its meeting of January 16, 1947, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute.

To Grade of Fellow

Ball, R. D., chief designer, Aircraft Elec. Machines; consultant, English Elec. Co., Carr Lane Works; Bradford, England.
Caldwell, E., genl. mgr. & vice-pres., Hyster Co., Portland, Oreg.
Cannady, N. E., N. C. state elec. engr. & inspector, Insurance Dept.; Raleigh, N. C.

3 to grade of Fellow

To Grade of Member

Anderson, W. A., project engineer, Armstrong Cork Co., Lancaster, Pa.
Bereskin, A. B., associate prof. of elec. engg., Univ. of Cincinnati, Ohio.
Cook, L. W., chief engineer, Simmons Co., electronic blanket div., New York, N. Y.
Gebuhr, J. V., associate, Brown Engg. Co.; C.E.; Des Moines, Iowa.
Graham, A. L., mgr., specialty trans. div., Canadian General Elec. Co., Toronto, Ontario, Canada.
Grandi, L. L., associate prof., elec. engg. dept. A & M College of Texas, College Station, Tex.
Hamilton, H. L., corrosion engineer, Keystone Pipe Line Co. & Buffalo Pipe Line Corp., Phila., Pa.
Horne, W. H., Jr., electrical contractor; owner, W. H. Horne, Jr., Warrentown, N. C.
Humbert, W. F., plant engg., Marshall Field & Co., mfgr. div., Spray, N. C.
Jarvis, G. B., equipment & bldg. engineer, Indiana, Bell Tel. Co., Indianapolis, Ind.
Kane, E. D., asst. supervisor, standards lab., The Detroit Edison Co., Detroit, Mich.
Link, J. H., elec. engineer, Bureau of Ships, U. S. Navy Dept., Washington, D. C.
Poindexter, V. J., supt. of elec. operations, Eugene Water Board, Eugene, Oreg.
Poole, L. C., consulting & application engineer, Westinghouse Elec. Corp., Cleveland, Ohio.
Schenck, H. H., radio engineer, International Tel. & Tel. Co., New York, N. Y.
Schweers, C. W., dist. mgr., Allis-Chalmers Mfgr. Co., Houston, Tex.
Small, B. I., elec. engineer, (*P-4*), U. S. Naval Research Lab., Washington, D. C.
Steinbright, W. G., div. supt., Philadelphia Elec. Co., Norristown, Pa.
Wages, W. L., chief, trans. system maintenance staff, Tennessee Valley Authority, Chattanooga, Tenn.

19 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before March 21, 1947, or May 21, 1947, if the applicant resides outside of the United States or Canada.

To Grade of Member

Abrahams, A. A., Federal Oil Burner Co., Inc., Philadelphia, Pa.
Armstrong, C. A., N. Y. Tel. Co., New York, N. Y.
Barry, W. C., W. T. Henley's Telegraph Works Co., Ltd., Gravesend, Kent, England.
Beedy, H., Western Elec. Co., Inc., Chicago, Ill.
Burgess, W. D., El Paso Elec. Co., El Paso, Tex.
Caruthers, R. S., Bell Tel. Labs., New York, N. Y.
Chaput, O., Aluminum Labs. Ltd., Montreal, Quebec, Canada.
Clark, G. G., Ohio Bell Tel. Co., Cleveland, Ohio.
Cox, R. D., Florida Pr. & Lt. Co., W. Palm Beach, Fla.
Davis, L. A. W., Naval Service Headquarters, Ottawa, Ontario, Canada.
Diamond, B. S., The Commercial Cable Co., New York, N. Y.
Distad, M. F., Naval Research Lab., Washington, D. C.

Elliott, D. F., Alabama Pr. Co., Birmingham, Ala.
Erickson, L. G., Lenkurt Elec. Co., San Francisco, Calif.
Fletcher, L., Naval Service Headquarters, Ottawa, Ontario, Canada.
Furse, E. D., Pan American Grace Airways, Limatambo, Lima, Peru.
Gaylard, R. P., Naval Service Headquarters, Ottawa, Ontario, Canada.
Graham, V. M. (re-election) Sylvania Elec. Products, Inc., Flushing, N. Y.
Gregory, H. S., 1511 Louisiana Ave., New Orleans, La.
Grout, R. E., The Shawinigan Engg. Co., Ltd., Montreal, Quebec, Canada.
Haig, H. B., General Elec. Co., Schenectady, N. Y.
Harrison, L. H., U. S. Bureau of Mines, Birmingham, Ala.
Hastings, A. W., Engineers Public Service Co., Inc., New York, N. Y.
Imhoff, E. A., Chicago Rapid Transit Co., Chicago, Ill.
Ironside, H. N., Pacific Gas & Elec. Co., Oakland, Calif.
Jentzen, W. H., Southern Bell Tel. & Tel. Co., Atlanta, Ga.
Johnson, R. G., Public Utility Eng. & Service Corp., Chicago, Ill.
Jonsson, N. F., Spring Garden Institute, Philadelphia, Pa.
Kahn, A., RCA Labs., New York, N. Y.
Khan, A. H., Tata Iron & Steel Co., Ltd., Jamshedpur, India.
King, C. S., Sacramento Municipal Utility Dist., Sacramento, Calif.
Kunz, W. J., Jr., Bendix Aviation Corp., Teterboro, N. J.
La Mothe, D. J., Purdue University, Lafayette, Ind.
Mann, F. J., Int'l Tel. & Tel. Corp., New York, N. Y.
Matthews, R. F., U. S. Dept. of Commerce, Washington, D. C.
McKissack, J. R., U. S. Naval Hospital, Portsmouth, Va.
Mendenhall, C. J., Allied Engineering Co., Cleveland, Ohio.
Michon, A. E., Western Union Telegraph Co., New York, N. Y.
Muldoon, W. J., Guided Radio Corp., New York, N. Y.
Nettnin, L. H., Nelson & Nettnin, Inc., Chicago, Ill.
Nordlier, B. W., 7614 S. E. Seventeenth Avenue, Portland, Oreg.
Osborne, M. R., Osborne Elec., Inc., Oklahoma City, Okla.
Pittman, D. D., Locke Insulator Corp., Chicago, Ill.
Rabb, J. W., Naval Research Lab., North Beach, Md.
Roehm, J. M., Buehler & Co., Chicago, Ill.
Roush, R. B., Pennsylvania Pr. & Lt. Co., Allentown, Pa.
Saleh, A. B. M., Universal Engg. & Trading Co., Inc., Cairo, Egypt.
Sandorf, I. J., Univ. of Nevada, Reno, Nev.
Satchwell, T. E., Jr., Satchwell & Joseph Elec. Co., Jacksonville, Fla.
Schreck, R. D., Westinghouse Elec. Corp., New York, N. Y.
Slonczewski, T., Bell Tel. Labs, Inc., New York, N. Y.
Stuart, J. M., The Dayton Pr. & Lt. Co., Dayton, Ohio.
Swain, F. E., U. S. Bureau of Reclamation, Denver, Colo.
Taft, G. R., General Elec. Co., Philadelphia, Pa.
Turner, F. E., Naval Service Headquarters, Ottawa, Ontario, Canada.
Utley, V., U. S. Drydock & Repair Facility Miramar, San Juan, Puerto Rico.
Waghorne, J. H., Hydro-Elec. Power Comm. of Ont., Toronto, Ontario, Canada.
Waldner, C. E., New York Tel. Co., Brooklyn, N. Y.
Watrous, W. W., Jr., Westinghouse Elec. Corp., Bloomfield, N. J.
Weiss, W. A., Hickok Elec. Instr. Co., Cleveland, Ohio.
White, C. G., City of Anchorage Pr. & Tel. Systems, Anchorage, Alaska.
Wilcox, G. E., Naval Research Lab., Washington, D. C.
Williams, S. A., Bastian & Allen, Ltd., London, England.
Woll, W. N., Commonwealth Edison Co., Chicago, Ill.
Young, G. A., Naval Service Headquarters, Ottawa, Ontario, Canada.

65 to grade of Member

To Grade of Associate

United States, Canada, and Mexico

1. North Eastern

Atwell, R. G., 1388 Bridge St., Lowell, Mass.
Bartlett, W. D., General Elec. Co., Lynn, Mass.
Bernier, J. A., General Elec. Co., Schenectady, N. Y.
Blythe, E. G., Boston Naval Shipyard, Charlestown, Mass.
Bondy, M. F., Raytheon Mfg. Co., Waltham, Mass.
Boyle, M. V., General Elec. Co., Schenectady, N. Y.
Burnup, E. C., Jr., Rochester Gas & Elec. Corp., Rochester, N. Y.
Devoe, C. L., Charles L. Devoe Co., Inc., Boston, Mass.
Di Cicco, V., The Foxboro Co., Foxboro, Mass.
Dygve, E. S., General Elec. Co., Schenectady, N. Y.
Ewen, R. A., General Elec. Co., Schenectady, N. Y.
Glenn, J. M., Schick, Inc., St. Amford, Conn.
Greenfield, A., Remington-Rand, South Norwalk, Conn.
Heindsmann, T. E., Jr., USN Underwater Sound Lab., New London, Conn.
Hopkins, R. J., General Elec. Co., Pittsfield, Mass.
Hovhanesian, G., Telechron, Inc., Ashland, Mass.
Ishii, F. K., Chance Vought Aircraft Corp., Stratford, Conn.
Kelly, P. W., Boston Edison Co., Boston, Mass.
Krackhardt, R. H., Worcester Poly. Inst., Worcester, Mass.
Lahana, P., Rensselaer Poly. Inst., Troy, N. Y.
Lawhead, R. E., Jr., Int'l Business Machines Corp., Endicott, N. Y.
Lawrence, G. D., 97 Bay State Rd., Boston, Mass.
Lee, D. S., Rockbestos Products Corp., Buffalo, N. Y.
Manning, E. G., Eastman Kodak Co., Rochester, N. Y.
Mele, B. T., General Precision Lab., Inc., Pleasantville, N. Y.
Morse, J. E., Eastman Kodak Co., Rochester, N. Y.
Norton, R. S., General Precision Lab., Inc., Pleasantville, N. Y.
Palmer, F. W., Boston Edison Co., Boston, Mass.
Procopion, S. J., P. O. Box 411, Waterbury, Conn.
Raymond, R. L., Buffalo Niagara Elec. Corp., Tonawanda, N. Y.
Sawers, E. H., Cornell University, Ithaca, N. Y.
Smith, R. F., General Elec. Co., Lynn, Mass.
Soorsoorian, S. A., 51 Merrimac St., Newburyport, Mass.
Stakutis, A. P., Stone & Webster Eng. Corp., Boston, Mass.
Webb, W., Int'l Business Machines, Endicott, N. Y.

2. Middle Eastern

Albert, G. J., Naval Research Lab., Washington, D. C.
Ashton, C. H. (re-election), 2041 Chestnut St., Philadelphia, Pa.
Askew, W. H., Naval Research Lab., Washington, D. C.
Barlow, H. B., Jr., Dept. of Commerce, Washington, D. C.
Barrios, C. J., Westinghouse Elec. Corp., Pittsburgh, Pa.
Beik, H. F., University of Delaware, Newark, Del.
Bell, H. F., Ford, Bacon & Davis, Inc., Charleston, W. Va.
Boddie, C. A. (re-election), Office of Chief Signal Officer, USA, Washington, D. C.
Bonacker, H. C., Ohio Bell Tel. Co., Cleveland, Ohio.
Boswick, M. C., The A-C Supply Co., Curahoga Falls, Ohio.
Botwin, L., Ohio State University, Columbus, Ohio.
Bradley, W. D., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Brunner, H. C. (re-election), Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Bryant, W. C., Civil Aeronautics Administration, Washington, D. C.
Bunnin, F. C., Ohio Bell Tel. Co., Cleveland, Ohio.
Cisneros, F., Westinghouse Elec. Corp., Pittsburgh, Pa.
Cochran, P. L., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Crow, F. L., General Elec. Co., Erie, Pa.
Demmy, R. H., Scranton Elec. Co., Scranton, Pa.
Donnelly, T. J., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Downing, J. R., Jr., Westinghouse Elec. Corp., Pittsburgh, Pa.
Drews, W. A., U. S. Civil Service Comm., Camp Detrick, Md.
Duff, J. M., Reliance Elec. & Engg. Co., Cleveland, Ohio.
Earley, J. F. A., Bradley Co., Inc., Philadelphia, Pa.
Emrick, H. W., Ohio Brass Co., Barberton, Ohio.
Esden, R. M., Pereny Equipment Co., Columbus, Ohio.
Fellendorf, G. W., Western Elec. Co., Allentown, Pa.
Fischer, P. M., Pittsburgh Plate Glass Co., Barberton, Ohio.
Fisher, S. G., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Folberth, G. W., Glenn L. Martin Co., Baltimore, Md.
Fuller, T., Westinghouse Elec. Corp., Washington, D. C.
Gieseler, L. P., Naval Ordnance Lab., White Oak, Md.
Goetzke, G. A., Jr., Ensign, USNR, Bureau of Naval Personnel, Washington, D. C.
Gruber, F., Glenn L. Martin Co., Baltimore, Md.
Guerra, L., Westinghouse Elec. Corp., Pittsburgh, Pa.
Hagerling, S. W., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Hanna, R. R., Koppers Coal Division, Powellton, W. Va.
Harper, R. W., Reliance Elec. & Engg. Co., Cleveland, Ohio.
Ho, T. S., Central Elec. Works of China, c/o 7137 Penn Ave., Pittsburgh, Pa.
Hoffman, G. R., I-T-E Circuit Breaker Co., Philadelphia, Pa.
Hopkins, C. D., General Elec. Co., Philadelphia, Pa.
Hornfeck, L. W., J. P. Warner, Pittsburgh, Pa.
Hufnagel, J. G., Locke Insulator Corp., Baltimore, Md.
Hugus, C. E., Jr., Reliance Elec. & Engg. Co., Cleveland, Ohio.
Johnson, C. W., The Ohio Bell Tel. Co., Cleveland, Ohio.
Johnson, H. D., Hickok Electrical Inst. Co., Cleveland, Ohio.
Klyne, J. A., Westinghouse Elec. Corp., Cleveland, Ohio.
Koenig, L. A., Elec. Products Co., Cleveland, Ohio.
Kroger, W. A., Jr., American Tel. & Tel. Co., Cincinnati, Ohio.
Kueppers, F. A., The Maryland Drydock Co., Baltimore, Md.
Kurtz, R. S., Heinemann Elec. Co., Trenton, N. J.
Little, H. W., Crown Cork & Seal Co., Baltimore, Md.
Mahler, J., Air Inst. of Technology, Dayton, Ohio.
Marlowe, E. W., Union Switch & Signal Co., Pittsburgh, Pa.
Marquardt, H. W., c/o Westinghouse Mfg. Lab., Forest Hills, Pa.
McKune, W. J., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Muckley, C. J., The Timken Roller Bearing Co., Canton, Ohio.
Montgomery, W. L., Duquesne Light Co., Pittsburgh, Pa.
Murtland, J. B., Jr., Aluminum Co. of America, New Kensington, Pa.
Nielsen, C. J., General Elec. Co., Erie, Pa.
Peck, C. E. (re-election), Westinghouse Elec. Corp., Meadville, Pa.
Pleshek, L. J., Air Matèriel Command, Wright Field, Dayton, Ohio.
Randack, J. F., Jr., Army Air Forces, Wright Field, Dayton, Ohio.
Raymond, T. E., Jr., Simplex Engg. Co., Zanesville, Ohio.
Sampaio, J. A., Jr., Westinghouse Elec. Corp., Pittsburgh, Pa.
Saunders, B. H., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Schwindig, A. E., Ohio Bell Tel. Co., Cleveland, Ohio.
Sherman, A., General Elec. Co., Erie, Pa.
Speer, D. S. (re-election) Pittsburgh Plate Glass Co., Creighton, Pa.
Stitt, J. C. (re-election), General Elec. Co., Cleveland, Ohio.
Sullivan, W. B., Potomac Elec. Pr. Co., Washington, D. C.
Toth, A. J., Ohio Bell Tel. Co., Cleveland, Ohio.
Valente, A., Westinghouse Elec. Corp., Philadelphia, Pa.
Wagner, C. L., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Wen, C. C., Westinghouse Elec. Corp., E. Pittsburgh, Pa.

3. New York City

Ajzenberg, F., 23 West 73rd St., New York, N. Y.
Allen, L., Western Elec. Co., New York, N. Y.
Alterman, F. J., Reeves Inst. Corp., New York, N. Y.
Argintar, H., 1746 Andrews Ave., New York, N. Y.
Aye, F. W., National Resources Comm. of Chinese Govt., c/o 111 Broadway, New York, N. Y.
Black, L. D., Jr., Rambusch Decorating Co., New York, N. Y.
Bodnar, F. P., Ebasco Services, New York, N. Y.
Carluccio, J., National Union Radio Corp., Orange, N. J.
Collins, J. J., US Navy Supply Base, Port Newark, N. J.
Cushing, P., Jr., Electrons, Inc., Newark, N. J.
Dagavarian, H. O., Sylvania Elec. Products, Inc., Kew Gardens, N. Y.
Daniels, M. D., Curtiss-Wright Corp., Caldwell, N. J.
Dean, N. J., Columbia University, New York, N. Y.
De Anna, J. C., Western Elec. Co., Inc., Newark, N. J.
DeCew, R. E., 290 Claremont Ave., Mount Vernon, N. Y.
Fuss, E. L., American District Tel. Co., New York N. Y.
Gilbert, J., Norden Labs., New York, N. Y.
Harris, L., 140 East Second St., Brooklyn, N. Y.
Harrison, R. I., College of the City of N. Y., New York, N. Y.
Hecht, H., New York Naval Shipyard, Brooklyn, N. Y.
Hoffman, W. E., Thomas A. Edison, Inc., West Orange, N. J.
Hotte, A. P. L., Dictaphone Corp., New York, N. Y.
Hunicke, R. L., Standard Oil Development Co., Elizabeth, N. J.
Jakubowski, M. C., Fairchild Aerial Surveys, Inc., Long Island City, N. Y.
Jones, S. A., The Schuyler Hopper Co., New York, N. Y.
Kahrilas, P. J., Hazeltine Electronic Corp., Little Neck, N. Y.
Krauzer, E. I., American Transformer Co., Newark, N. J.
Kreider, D. M., American Tel. & Tel. Co., New York, N. Y.
LeVine, D. J., Microwave Research Inst., Brooklyn, N. Y.
Lynn, S., Western Elec. Co., Newark, N. J.
McCarthy, P. J., Dept. of Water Supply, Gas & Electricity, New York, N. Y.
McDonough, V.T., Western Elec. Co., Kearny, N. J.
Mortenson, E. M., Western Union Telegraph Co., New York, N. Y.
Moses, K., College of the City of New York, New York, N. Y.
Osteyee, K. C., Raymond M. Wilmotte, Inc., New York, N. Y.
Panoff, J. E., 302 Rochester Ave., Brooklyn, N. Y.
Panzen, W., Press Service, New York, N. Y.
Pelletier, R. A., 566 E. Walnut St., Long Beach, N. Y.
Peterson, J. D. (re-election), Bendix Aviation Corp., Teterboro, N. J.

Renfree, E. W., US Rubber Co., New York, N. Y.
Roberts, F. B., North American Philips, Dobbs Ferry, N. Y.
Robinson, I. E., Hazeltine Electronics Corp., Little Neck, N. Y.
Rosenberg, A. E., Lexington Elec. Products Co., Inc., Newark, N. J.
Schellhardt, L. F., Delaware, Lackawanna & Western RR Co., Hoboken, N. J.
Seale, A. C., Jr., Long Island Lighting Co., Mineola, N. Y.
Souder, C. W., Sperry Gyroscope Co., Garden City, N. Y.
Stahr, R. G., USS *Stormes*, c/o FPO, New York, N. Y.
Stephenson, S. S., Jr., Otis Elevator Co., New York, N. Y.
Taffuri, M. L., Eastern Air Devices, Brooklyn, N. Y.
Thompson, L. B., N. J. Bell Tel. Co., Newark, N. J.
Toner, J. W., Federal Tel. & Radio Corp., Clifton N. J.
Troxell, C. G., Public Service Elec. & Gas Co., Newark, N. J.
Webb, G. W., 220K Army Hall, 1560 Amsterdam Ave., New York, N. Y.
Zelaya, S. H., Westinghouse Int'l Co., New York, N. Y.
Zenobia, D. I., H. A. Wilson Co., Newark, N. J.

4. Southern

Adams, J. N., Jr., Florida Pr. & Lt. Co., Miami, Fla.
Bivans, E. L., Florida Pr. & Lt. Co., Miami, Fla.
Brass, E. A., Southern Switch & Signal Co., Shreveport, La.
Carson, J. B., Kingsport Elec. Co., Inc., Kingsport, Tenn.
Davis, P. E., Jr., E. P. McLean Engg. Co., Moultrie, Ga.
Dusina, L., University of Kentucky, Lexington, Ky.
Falls, M. P., Clinton Labs., Oak Ridge, Tenn.
Goddard, G. A., Locke Insulator Corp., Atlanta, Ga.
Gore, D. J., Carolina Pr. & Lt. Co., Raleigh, N. C.
Gorman, J. G., University of Virginia, Charlottesville, Va.
Griffin, J. D., South East Joslyn Co., Jacksonville, Fla.
Hendon, C. J., General Elec. Co., Atlanta, Ga.
Hinton, O. T., Jr., Poinsett Lumber & Mfg. Co., Pickens, S. C.
Lentz, K. A., Jr., Westinghouse Elec. Corp., Louisville, Ky.
MacCarthy, H. P., Florida Pr. & Lt. Co., Miami, Fla.
McLemore, G. R., Southwestern Gas & Elec. Co., Shreveport, La.
Peery, G. M., Virginia Polytechnic Inst., Blacksburg, Va.
Pfitzer, A. C., Jr., TVA, Chattanooga, Tenn.
Pilgrim, J. A., Commonwealth & Southern Corp., Birmingham, Ala.
Randolph, A. M., Southwestern Gas & Elec. Co., Shreveport, La.
Reeder, F. B., Florida Pr. & Lt. Co., Miami, Fla.
Schaeffer, H. A., Jr., The Flintkote Co., New Orleans, La.
Sewell, C. E., Jr., American Elevator & Machine Co., Louisville, Ky.
Spivey, H. R., TVA, Chattanooga, Tenn.
Swingle, T. M., TVA, Chattanooga, Tenn.
Thue, W. D., Florida Pr. & Lt. Co., Miami, Fla.
Towson, H. N., Florida Pr. & Lt. Co., Miami, Fla.
Vernon, H. L., Alabama Pr. Co., Birmingham, Ala.
Williams, M. L., lieut. col., Signal Corps, US Army, Fort Bragg, N. C.
Williams, R. O., Southern Bell Tel. & Tel. Co., Shreveport, La.
Winn, E. B., University of Virginia, Charlottesville, Va.

5. Great Lakes

Bachman, W. W., Amer. Tel. & Tel. Co., Chicago, Ill.
Baird, R. V., Underwriters' Labs., Inc., Chicago, Ill.
Beveridge, T., Koontz-Wagner, South Bend, Ind.
Black, R. H., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bragg, C. E., Standard Oil Co., Whiting, Ind.
Brede, D. W., Detroit Edison Co., Detroit, Mich.
Casciaro, E. R., 1006 Wisconsin Ave., Racine, Wis.
Chapin, C., Dept. of Water Supply, Detroit, Mich.
Cooper, C. W., Public Service Co. of No. Ill., Chicago, Ill.
Culbertson, A. F., American Tel. & Tel. Co., Joliet, Ill.
Endahl, J. C., General Elec. Co., Davenport, Iowa.
Eouyang, C., Detroit Edison Co., Detroit, Mich.
Feng, T. N., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Foss, J. C., Commonwealth Edison Co., Chicago, Ill.
Freundlich, G. H., Public Service Co. of No. Ill., Glencoe, Ill.
Fullerton, E. A., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Goss, K. J., Consumers Pr. Co., Jackson, Mich.
Gray, L. C., Koontz-Wagner Elec. Co., Inc., South Bend, Ind.
Hanks, S. V., Chicago Thrift Co., Chicago, Ill.
Heyes, A. B., Chicago Rapid Transit, Chicago, Ill.
Hiatt, M. E., Associated Engineers, Inc., Ft. Wayne, Ind.
Iffland, C. F., Northwestern University, Evanston, Ill.
Jensen, A., Commonwealth Edison Co., Chicago, Ill.
Jones, R. E., University of Chicago, Chicago, Ill.
Keefer, T. B., Weston Elec. Instrument Corp., Chicago, Ill.
Klos, E. R., Geo. Gorton Mach. Co., Racine, Wis.
Knopow, H. S., Harnischfeger Corp., Milwaukee, Wis.
Kralovec, E. M., Jr., Sargent & Lundy, Chicago, Ill.
Kvarnstrom, L. D., Super Elec. Constr. Co., Chicago, Ill.
Lagerstrom, J. E., Iowa State College, Ames, Iowa.
Larsen, O. R., Commonwealth Edison Co., Chicago, Ill.
Lewis, H. R. (re-election), Commonwealth Edison Co., Chicago, Ill.
Light, E. J., Commonwealth & Southern Corp., Jackson, Mich.
Loos, R. F., Allis-Chalmers Mfg., Milwaukee, Wis.
Moody, J. M., Jr., Iowa Inst. of Hydraulics, Iowa City, Iowa.
Nordmark, A. N., Commonwealth Edison Co., Chicago, Ill.
O'Day, L. P., General Motors Corp., La Grange, Ill.
O'Laughlin, M. J., Northern Indiana Public Service Co., Hammond, Ind.
Peschel, W. F., Fenn College, Cleveland, Ohio.
Pickens, D. H., Illinois Inst. of Tech., Chicago, Ill.
Rawles, C. M., Jr., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Raymond, R. G., Illinois Bell Tel. Co., Chicago, Ill.
Rendell, D. J., Commonwealth Edison Co., Chicago, Ill.
Sayre, J. A., Iowa Pr. & Lt. Co., Des Moines, Iowa.
Schilling, H. W., Commonwealth Edison Co., Chicago, Ill.
Simpson, F. H., Lehigh Portland Cement Co., Mitchell, Ind.
Sivertsen, S. M., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Smith, W. P., Waldo I. Scott, Watertown, S. Dak.
Spitz, A. H., General Motors Corp., La Grange, Ill.
VanDeventer, J. B., Peoria Central High School, Peoria, Ill.
Ward, A. J., Sargent & Lundy, Engrs., Chicago, Ill.
Watson, H. B., Consumers Pr. Co., Jackson, Mich.
Whiteman, C. F., Ohio Power Co., Philo, Ohio.
Wiersema, H., Commonwealth Edison Co., Chicago, Ill.
Wood, F. M., Commonwealth Edison Co., Chicago, Ill.
Wuest, M. G., Pittsburgh Plate Glass Co., Barberton, Ohio.

6. North Central

Britt, H. O., US Bureau of Reclamation, Denver, Colo.
Costa, J. P., Bureau of Reclamation, Denver, Colo.
Hicks, J. T., US Bureau of Reclamation, Guernsey, Wyo.
Hong, H. F., Natl. Resources Comm. of China, c/o Bureau of Reclamation, Denver, Colo.
Martin, J. E., University of Denver, Denver, Colo.
Moomaw, G. C., Consumers Public Pr. Dist., Lincoln, Nebr.

7. South West

Argo, D. E., A. B. Chance Co., Houston, Tex.
Bass, H. S., Houston Lighting & Pr. Co., Houston, Tex.
Bottoms, J. B., Southwestern Public Service Co., Amarillo, Tex.
Burns, R. C., Carter Oil Co., Tulsa, Okla.
Cook, W. L., Westinghouse Elec. Corp., Houston, Tex.
Dulin, J. J., University of Arkansas, Fayetteville, Ark.
FitzHugh, P. M., University of Houston, Houston, Tex.
Fligor, L. G., Southwestern Bell Tel. Co., St. Louis, Mo.
Hatfield, H. W., General Elec. Supply Corp., Kansas City, Mo.
Jansen, H. B., Albert Kahn, Associated, Robertson, Mo.
Makeig, C. S., Southwestern Elec. Service Co., Waco, Tex.
Milks, W. C., Jr., Wagner Elec. Corp., St. Louis, Mo.
Minx, C. C., Southwestern Bell Tel. Co., St. Louis, Mo.
Moore, O. E., Southwestern Public Service Co., Clovis, New Mex.
Newman, R. B., Reynolds Metals Co., Jones Mills, Ark.
Pillep, E. R., Union Elec. Co. of Mo., St. Louis, Mo.
Poole, K. J., Poole Elec. Co., Little Rock, Ark.
Rippey, G. E., American Tel. & Tel. Co., St. Louis, Mo.
Saye, H. A., Jr., 2014 Rosewood St., Houston, Tex.
Seymour, F., Reg. F. Taylor, Houston, Tex.
Smith, W. R., Southwestern Public Service Co., Plainview, Tex.
Streater, L. C., Westinghouse Elec. Corp., Dallas, Tex.
Tatum, J. E., Southwestern Public Service Co., Amarillo, Tex.
Wheeler, E. B., Southwestern Bell Tel. Co., Houston, Tex.

8. Pacific

Baldwin, A. T., California Tel. Co., San Diego, Calif.
Baus, P. R., Jack & Heintz Precision Industries, Inc., Burbank, Calif.
Creim, D. H., A. B. Chance Co., San Francisco, Calif.
Dauwalder, K. C., Southern Calif. Tel. Co., Los Angeles, Calif.
Davis, W. A., San Diego Gas & Elec. Co., San Diego, Calif.
Geasland, R. I., Southern Calif. Tel. Co., Los Angeles, Calif.
Higashiuchi, A., 237 State Street, Los Altos, Calif.
Hussey, H. L., Phelps Dodge Copper Products Corp., San Francisco, Calif.
Ives, H. F., The Tucson Gas, Elec. Lt. & Pr. Co., Tucson, Ariz.
Jacobs, H., Jr., North American Aviation, Inc., Los Angeles, Calif.
Means, L. E., J. M. Montgomery & Co., Henderson, Nev.
Morris, A. J., US Navy Office of Naval Research, San Francisco, Calif.
Preizner, F. L., Arizona Edison Co., Inc., Phoenix, Ariz.
Proszek, E. L., Ames Aeronautical Lab., Moffett Field, Calif.
Ranson, M. R., Harvey Machine Co., Los Angeles, Calif.
Reed, C. W., North American Aviation, Los Angeles, Calif.
Seidl, A., Pacific Gas & Elec. Co., San Francisco, Calif.
Smith, M. C., 525 So. Ardmore Ave., Los Angeles, Calif.
Snyder, W., Hughes Aircraft Co., Culver City, Calif.
Wallace, W. J., Pacific Gas & Elec Co., San Francisco, Calif.
Warth, R. C., Tucson Gas, Elec. Lt. & Pr. Co., Tucson, Ariz.
Wettstein, J. E., 2710½ Bryant St., San Francisco, Calif.
Wright, H. F., Pacific Gas and Elec. Co., Emeryville, Calif.

9. North West

Bolien, F. A., Portland General Elec. Co., Portland, Oreg.
Brown, B. H., The Pacific Tel. and Tel. Co., Portland, Oreg.
Greiner, R. C., US Bureau of Reclamation, Coulee Dam, Wash.
James, M. B., Northwestern Agencies, Seattle, Wash.
Jones, J., 7555—31st Ave., N.E., Seattle, Wash.
Klein, K. M. (re-election), Bonneville Pr. Admn., Portland, Oreg.
Mather, R. J., Jr., Bonneville Pr. Admn., Portland, Oreg.
Ray, J. A. (re-election), Portland General Elec. Co., Portland, Oreg.
Rehkopf, G. R., Puget Sound Pr. & Lt. Co., Everett, Wash.
Scofield, G. J., G. E. X-Ray Corp., Salt Lake City, Utah.

10. Canada

Aspinall, R. H., Ont. Hydro-Elec. Pr. Comm., Toronto, Ontario, Canada.
Bartlett, O. W. (re-election), Fraser-Brace Engg. Co., Ltd., Montreal, Quebec, Canada.
Bodnar, M. W., B. C. Elec. Co., Ltd., Vancouver, British Columbia, Canada.
Broe, K. L., Canadian General Elec. Co., Toronto, Ontario, Canada.
Cary, L. S., Canadian Westinghouse, Ltd., Hamilton, Ontario, Canada.
Cooper, A. S., Moloney Elec. Co., Ltd., Toronto, Ontario, Canada.
Dickson, T. E., C. A. Parsons & Co., Toronto, Ontario, Canada.
Eckersley, R. A., Canadian General Elec. Co., Ltd., Toronto, Ontario, Canada.
Ford, J. H. S., Canadian National Telegraphs, Toronto, Ontario, Canada.
Guest, D. E., Somervilles, Ltd., Buckingham, Quebec, Canada.
Lee, H-T, 320 Elm St., Montreal, Quebec, Canada.
Linney, J. A., Canadian National Railways, Montreal, Quebec, Canada.
McAllister, R. D., Consolidated Mining & Smelting Co. of Canada, Ltd., Trail, British Columbia, Canada.
Reback, T., Supreme Pr. Supplies, Mimico, Ontario, Canada.
Sansum, J. D., Canadian Industries, Ltd., Shawinigan Falls, Quebec, Canada.
Shopsowitz, D., University of Toronto, Toronto, Ontario, Canada.
Weedmark, N. J., The International Nickel Co. of Canada, Ltd., Turbine, Ontario, Canada.

Elsewhere

Chaudhuri, M., Imperial College, London, England.
Easterbrook, L. J., Jr., Int'l Tel. & Tel. Corp., Habana, Cuba.
Hasan, S. A., c/o Central Electricity Board, Birmingham, England.
Hsu, S. Y., Kiangnah Pr. Admn., Shanghai, China.
Kazak, E. D., Shanghai Tel. Co., Shanghai, China.
Peikes, A. P., Bahamas Telecommunications System, Nassau, Bahamas.
Ruddock, W. W., Maui Pineapple Co., Ltd., Kahului, Maui, Hawaii.
Satyendra, K. N., GIP Railway Office, Parel, Bombay, India.
Saxby, C. A., Dept. of Public Works, Sydney, New South Wales, Australia
Sommerguth, H. E., Sigmund Pumps Ltd., Gateshead, England.
Vrethem, A. T., Royal Board of Waterfalls, Stockholm, Sweden.
Wang, T-C, Chungking Pr. Co., Chungking, China.

Total to grade of Associate

United States, Canada, and Mexico, 332
Elsewhere, 12

OF CURRENT INTEREST

AIEE Meeting Visitors Also Attend Electrical Exposition

Silicones, portable testing devices, and induction heating were among the most popular of the 65 exhibits and demonstrations at the Electrical Engineering Exposition held in the 71st Regiment Armory, New York, N. Y., concurrently with the AIEE winter meeting. A transmission line construction truck built to carry tools, supplies, and equipment for power line construction also was a prominent feature of the exposition, which was said to be especially successful from the viewpoint of personal interviews with manufacturers and the widening of personal contacts.

One of the latest of silicone developments is a thermosetting resin developed and produced for use as a heat-stable bonding material for inorganic fabrics in the production of rigid electrical laminates and for bonding finely divided particles such as powdered metals or mica, silica or carbon. Silastic, the silicone rubber featured in the display, was illustrated with samples of molded and extruded, coated, and laminated products.

Several types of cathode-ray oscillograph designed for use in specific industrial fields and an inexpensive instrument for routine laboratory and production testing were displayed. Suggested uses included the study and testing of radio and television receivers, transmitters, welding circuits, transmission lines, electronic control devices, circuit breakers, and relays.

Shown for the first time was an oscilloscope weighing less than six pounds which can be carried in one hand. Two other new developments in test equipment included a wattmeter and an electric tachometer for measuring speeds as low as one fourth of one revolution per minute.

Infrared industrial heating was represented by a new type of prefabricated oven which provides zoned heating in two stages: preheating by convection and high speed temperature elevation by radiation, followed by heat retention for a predetermined time due to insulated construction.

Catalogues of enemy patents seized by the United States during the war were available at a booth representing the Office of the Alien Property Custodian. The price of the complete set of electrical mechanical abstracts had been reduced to $10.

Exhibitors stressed cost reduction features of their products, showing how prospective customers could reduce present costs through selection of improved devices. Scarcities of materials were still a large factor in the number of products displayed, as well as influencing the development of new products. For example, in one case the shortage of plain steel rod had led to the substitution of higher tensile strength steel, which made it possible to replace a one-inch alloy rod for a larger plain steel rod.

Other products exhibited were: control systems, motor-driven timers, oil-filled capacitors, sensitive relays, snap-action switches, and mercury contactors. There was also a new device for splicing loops in full tension copper overhead lines, as well as a new connector which provides a means for tapping an energized self-supporting aerial cable.

View of the exposition floor in the 71st Regiment Armory in New York

Edison Electric Institute Charges TVA With 1946 Deficit

The Tennessee Valley Authority showed an over-all deficit of $8,041,000 for fiscal 1946, ended last June 30, "after all costs, acknowledged and concealed," the Edison Electric Institute, representing approximately 75 per cent of the 15-billion-dollar electric light and power industry, asserted at a recent meeting. According to the institute this brings the grand total cost of the project to almost $100,000,000.

The EEI based its assertion on TVA's latest annual report showing a net power operating income of $16,213,724, net losses of $11,374,891 on such of its other operations as navigation, flood control, and chemical operations, and a "balance available for return on total investment" of $4,838,833. The industry association claimed that this balance would become a deficit if the interest which the United States Treasury paid on borrowed funds invested in the TVA plant were to be considered.

"In the face of all this, it seems remarkable how the TVA and its various protagonists can persist in maintaining that its electric rates are going to be sufficient to preserve the integrity of its investments."

This remark of the institute was aimed directly at the TVA's statement in its 1946 report that residential consumers of the Federal agency paid an average rate of 1.78 cents per kilowatt hour, compared with 3.31 cents elsewhere in the country.

"Far from being a business enterprise that must pay its way, it (the TVA) must be regarded as a public benefit subsidized by the Federal Treasury through Federal taxes.

"If this were a private enterprise, its rates would be high enough for it to bear its full share of Government," continued the institute's charge.

General Gibbs, of IT & T, Dies. Major General George Sabin Gibbs, United States Army, retired, and vice-president of the International Telephone and Telegraph Corporation, New York, N. Y., died January 9, 1947. General Gibbs, who was born in Harlan, Iowa, in 1875, held the degrees of bachelor of science (1897) and master of science (1901) from the State University of Iowa. He enlisted as a private in the United States Army in 1897, and fought in many engagements in the Philippines during the Spanish–American War. He won a

commission for bravery at the Battle of Manila, when he exposed himself to enemy fire in order to signal Admiral Dewey to cease firing, so that the Army could advance. After the war, he remained in the Signal Corps and spent two years in Alaska constructing telegraph lines for the Army. As a captain he was chief signal officer of the Army of Cuban Pacification in 1907. He went to France in 1917 as acting colonel and soon was made brigadier general and assistant chief signal officer of the American Expeditionary Forces. He was decorated with the Distinguished Service Medal and the French Legion of Honor. In 1924 he had charge of laying the cable from Seattle, Wash., to Alaska, and in 1928 was made chief signal officer with the rank of major general. He retired from the Army in 1931 and became vice-president of the International Telephone and Telegraph Corporation, and later that year, vice-president of the Postal Telegraph Cable Company.

Edison's Neighbors Celebrate His Hundredth Anniversary

The communities in which Thomas Edison lived and worked paid him tribute in celebrations of the hundredth anniversary of his birth, February 11.

At West Orange, N. J., his roll-top desk, sealed on the day of his death, October 18, 1931, was opened February 8, and an inventory made of its contents. On the same day the "Edison Pageant of Light" was presented in Fort Myers, Fla., the winter home of the inventor.

His son, former Governor Charles Edison, spoke at ceremonies, February 9, marking the dedication of a plaque in memory of the "Wizard of Menlo Park" by the residents of Menlo Park, N. J., where Edison worked for ten years to perfect the first incandescent lamp. All schools in the area observed his birthday on February 11, when winners of an essay contest on his life and works were announced. In the evening Norman R. Steiden, curator of the museum of the Edison Laboratories, East Orange, N. J., addressed the Forum Club.

At his birthplace, Milan, Ohio, a special 3-cent centennial stamp went on sale February 11, one day before it was sold at other post offices.

Edison Day in Missouri; Chicago Holds Memorial Dinner

By order of Governor Phil M. Donnelly, February 11, 1947, was designated "Thomas A. Edison Day" in Missouri. The Governor was the principal speaker at the Edison Centennial Banquet held in the Hotel Muehlebach in Kansas City.

Presiding at the dinner was C. M. Lytle (M'42) chairman of the AIEE Kansas City Section. Other guests were W. M. Hand, the last surviving Edison Pioneer in Missouri, and J. F. Porter, Jr., who presented a recorded interview with his father, a former Edison Pioneer, who was for many years president of the Kansas City Power and Light Company. The Institute of Radio Engineers, the Engineers Club, the Electric Association, and the Illuminating Engineering Society were joint sponsors with the AIEE of the banquet.

Programs on the radio and in the schools were part of the state-wide observance of the day.

CHICAGO DINNER

A Thomas A. Edison Centennial dinner was held February 10, at the Palmer House, Chicago, Ill., under the auspices of 14 engineering, electrical, and other organizations.

The occasion was planned as part of the nation-wide observance of the 100th anniversary of the inventor's birth. Charles Y. Freeman, chairman of the Commonwealth Edison Company, Chicago, was the principal speaker.

The participating organizations were: the AIEE, the Electric Association, the Illuminating Engineering Society, the Institute of Radio Engineers, the Western Society of Engineers, the Chicago Technical Societies Council, the Electrochemical Society, the Society of Motion Picture Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Chemical Society, the Society of Automotive Engineers, and the Museum of Science and Industry.

Professional Roster Placement Service Merges With USES

The placement service of the National Roster of Scientific and Professional Personnel was merged recently with the United States Employment Service National Clearing House. Registrants with executive, professional, and scientific qualifications and experience may be placed in contact with employers who need their services anywhere in the United States or overseas through 1,800 local state employment service offices.

The National Clearing House keeps an active file in Washington, D. C., of job orders which are received from local offices when these offices are unable to fill employer's needs locally. Also the local offices send information to Washington about applicants possessed of training and skill for which there is no suitable local employment opportunity. By this method the USES brings together at a central point job orders and applications which cannot be handled locally, but which there is a greater chance of filling successfully on a larger and more diversified scale.

Call Letters Changed. The call letters of the National Broadcasting Company's New York, N. Y., key station were changed recently from *WEAF* to *WNBC*. Originally licensed as *WEAF* in 1922 the station was the property of the American Telephone and Telegraph Company which sold it to NBC in 1926. The telephone company is claimed, through its operation of *WEAF*, to have pioneered the method of supporting broadcasting expense by selling time on the air to advertisers. At the same time of this new call letter assignment the Columbia Broadcasting System New York key station's designation was changed from *WABC* to *WCBS*. The Atlantic Broadcasting Corporation operated *WABC* for some time before it became a subsidiary of CBS.

Power Appropriations Higher for 1948 US Budget

Increased appropriations during fiscal 1948 were asked by President Truman in his annual budget message for practically all Federal agencies engaged in power operations. Included in the figures listed was a $250,000,000 lending fund for the Rural Electrification Administration, equal to its 1947 authorization. Bonneville Power Administration's allotment of $20,278,000 contains an amount necessary to construct 252 circuit miles of transmission line and six new substations. The Bonneville appropriation figure is $7,808,000 higher than that for fiscal 1947.

New budget estimates for the Southwestern Power Administration total $2,725,000, which is $4,882,400 less than the 1947 amount. An appropriation amounting to $27,057,500 was recommended for the Tennessee Valley Authority. Withdrawals from TVA revenues will be added to this amount to finance a $32,585,000 program of construction and acquisition.

Budgetary requests for the regulatory agencies also were above the appropriations received during fiscal 1947. The Atomic Energy Commission was recommended for an appropriation of $250,000,000, although President Truman announced that over $444,000,000 will be spent during the coming year on atomic research.

Hydroelectric Development in India. Three large-scale hydroelectric power projects—one of them nearly the scope of the United States Tennessee Valley Authority, and another to include a dam higher than Boulder in Colorado—have been given top priority by the Indian government in its drive for greater industrialization and the development of natural resources. Furthest advanced of the projects is the one on the Damodar River in Bengal and Bihar provinces, and it is estimated that the system will produce 200,000 kw. A similar system is planned for the Kusi River, a tributary of the Ganges, which lies in Nepal and Bihar provinces. The third major project, which is pending until the provincial government can complete financial arrangements, is intended for the Mahanadi River in Orissa province. The first two projects are scheduled for completion over a 10-year period and will cost approximately $315,000,000.

Wilson Appointment Completes Civilian Atomic Control

With the recent appointment of Carroll L. Wilson, former assistant to Doctor Karl T. Compton (F '31) as general manager of the Atomic Energy Commission, civilian direction displaced the Army from all but advisory and operational functions in the development and administration of atomic weapons.

The duty of the new general manager, as chief executive officer of the commission, will be to see that the orders and directives of the commission are carried out. Mr. Wilson, who is 36 years old, is on leave of absence from the National Research Corporation, Boston, Mass. After being graduated from Massachusetts Institute of Technology in 1928, he served as assistant to Doctor Compton for eight years. In 1936 he became special assistant to Doctor Vannevar Bush (F '24) in developing a program of administration of patents on inventions by staff members of Massachusetts Institute of Technology, Cambridge. In 1940 he became one of the two original members of the National Defense Research Committee. Later he was executive assistant to Doctor Bush in the Office of Scientific Research and Development. Loaned to the State Department by that office in 1945, he assisted in the preparation of the Acheson–Lilienthal report on atomic energy control. Since the establishment of the Atomic Energy Commission in October 1946, Mr. Wilson had been associated with it as a consultant.

Rural Electrification for United Kingdom

An agreement for a five-year electrification project to bring electric energy to 150,000 farms—practically all of those not already served with electricity—has been reached between the electric power companies and the National Farmers' Union in Great Britain. The plan was worked out two years ago, and no formal government approval is necessary because the plan does not require financial aid from the state. Before the project can be undertaken, however, priorities must be obtained for the necessary labor and materials.

Total cost of the project probably will reach $290,000,000 with estimates of materials and costs based on installation over the five-year period.

Government Monopoly Feared. The appointment of David E. Lilienthal, proponent of public power development, as chairman of the Atomic Energy Commission, is seen as an indication that the Government's atomic monopoly will continue, according to a recent canvass of public utility executives made by the New York *Times*. The executives foresee Federal power projects receiving the benefits of any research that may result in the generation of electricity by atomic energy. Though the selection of Mr. Lilienthal is viewed with disappointment, there is general agreement throughout the industry that, in its present stage of development, full control of atomic energy should be vested in the Government. However, the executives did express concern about the future industrial applications of atomic energy and were not hopeful that the Government will release any atomic patents. One company executive said that, in the light of possibilities for developments of processes that might set the Government up in a business that would be ruinous to an existing industry, no industry "can feel safe for its future." He added that the law creating the commission should contain a statement of policy that would relieve the anxiety of investors in industries "which could be destroyed under such circumstances."

FCC Hearing Clarifies Progress of Color Television

A three-day hearing on the petition of the Columbia Broadcasting System for the establishment of commercial standards for color television was held in the New York, N. Y., area in January as a preliminary to a final hearing in Washington, D. C., February 10, after which the Federal Communications Commission will reach a decision.

Representatives of the Radio Corporation of America and the A. B. Du Mont Laboratories opposed adoption of the CBS standards, maintaining that the CBS system is too restrictive as to size of picture, viewing angles, and brilliance. RCA declared its belief that color television transmission is four to five years away.

At the first all-day demonstration for the FCC, two CBS receivers were installed in the Federal court in New York, and a program was transmitted from the CBS television station atop the Chrysler Building. The program was repeated after it had been carried to Washington and back by coaxial cable, a test designed to show the feasibility of transmission on a network basis.

The following day the CBS receivers were demonstrated side by side with Du Mont black-and-white receivers. At the final demonstration in the Princeton, N. J., laboratories of RCA, the RCA all-electronic color system was demonstrated and compared with reproduction over black-and-white sets. This was the first public showing of the RCA color system over a radio link, a half-mile 520-megacycle radio circuit between a studio in the laboratories and the Penn Neck Community Club where the receivers were installed.

A device to offset obsolescence of black-and-white receivers, in the form of a small metal box about half the size of a cigar box, which will adapt color transmission for use by black-and-white receivers, also was demonstrated. Another feature of the demonstration was the first public showing of Philco's newest black-and-white projection receiver having a 15-by-20-inch screen.

Opponents of the CBS system criticized the size of its screen, which they asserted the company had been unable to enlarge in six years and which they attributed to the type of scanning disk used. The fact that the convex magnifying glasses covering the CBS picture tube were particularly receptive to overhead and window light also was pointed out.

The RCA system was attacked for the unevenness of color shown by two different receivers and between one sequence and another.

Generalization of Einstein Theory. Accomplishment of "the competent generalization of Einstein's great theory of 1915" was announced January 29 by Austrian-born Professor Erwin Schroedinger, of the school of physics in the Dublin Institute for Advanced Studies, Dublin, Eire. Doctor Schroedinger, in revealing his solution to a group of 20 professors and students, said that its effect was to relate the Einstein theory to electromagnetics and that it should express everything in field physics. He explained that he had arrived at his theory by relying on a general nonsymmetric affinity, whereas other scientists had failed to solve the problem because they used a symmetrical affinity with only 40 component parts, instead of a general one with 64. According to Doctor Schroedinger, the Einstein theory now becomes a special case, as it is purely geometrical.

Snow Formed Around Artificial Nucleus in Laboratory

Formation of snow in a laboratory cold chamber around artificial nucleuses is reported as a further development in the production of man-made snow (*EE, Jan '47, p 105*). The announcement was made by Doctor Irving Langmuir, V. J. Schaefer, and Doctor Bernard Vonnegut of the General Electric Company research laboratory, Schenectady, N. Y., at a meeting of the American Physical Society.

Best of the materials used is silver iodide. Among other foreign materials capable of acting as artificial nucleuses for producing snow are lead iodide, iodoform, iodine crystals, apatite, nephelite, wurtzite, zincite, and cerium oxide. Pointing out that a temperature of minus 31 degrees Fahrenheit is required for natural ice nucleuses to form spontaneously, and that natural snowstorms often occur at temperatures higher than this, Doctor Langmuir said that there is every reason to believe that nature often starts snowstorms with artificial nucleuses.

Each of the foreign nucleuses employed to initiate snowfall has a crystal structure similar to that of ice. In the experiments with silver iodide, a coated string was fed into a flame which changed the silver iodide coating to a gas. A jet of air blown over the flame cooled and diluted the gas, causing formation of an invisible "smoke" of extremely small silver iodide particles in crystalline form. This "smoke" then was collected and stored in a rubber bulb.

When the crystalline silver iodide was dispensed into a supercooled cloud in a cold chamber, snow resulted. The transformation from water to snow took place at a temperature of 15 degrees Fahrenheit, as contrasted with the minus 31 degrees necessary for spontaneous ice nucleuses. Lead iodide effected the transformation from water to snow at zero degree Fahrenheit.

Mexico Suffers Electricity Shortage

Shortage of water available to the hydroelectric plants serving some sections of San Luis Potosi, Michoacan, Jalisco, and Guanajuato, Mexico, has become acute, and service interruptions have been necessary to conserve the limited supply. In 1945 the rainy season, which lasts from May through September, was light and caused the lowest available water supply in Michoacan in 40 years. At San Luis Potosi the steam plant, which was built soley as a reserve for the interconnecting system, has been operating at full capacity for the past year and a half, except when fuel was not obtainable. At the present time entire sections of San Luis are blacked out at regular intervals.

Arrangements have been completed for the United States Navy Department to lease to Mexico until February 1, 1948, a 10,000-kw power train to alleviate power shortage conditions. The power train, which was built during the war for emergency standby reserve to insure continuity of service to Navy yards, was expected to be hooked into the Guanajuato power system of the American and Foreign Power Company at Celaya, Mexico, by February 1.

Negotiations for lease of the power train were conducted through the United States State Department by the staff of American power consultants headed by Edward Falck (A '40) former director of the wartime Office of War Utilities. The staff was retained by the Mexican Government last fall to advise it on both short- and long-term power planning in that country.

Radiotelephone Service. Restrictions on radiotelephone calls to and from Moscow, Union of Soviet Socialist Republics, were lifted recently and the service then extended to Kiev and Leningrad for general public use. The service between Russia and the United States was opened during the war and was limited to government officials, the United States embassy, and the press. Service to Palestine also has been returned to general public use after interruption by the war.

Wrecked Ships Supply Power. The 6,700-horsepower electric propulsion plant of the *SS Donbass III*, whose aft section remained intact when the tanker broke in two, soon will be tied into the Pacific Gas and Electric Company system at Eureka, Calif., to ease the load situation there. In Anchorage, Alaska, the *SS Sackett's Harbor*, which suffered the same fate as the *Donbass III*, will provide power to the municipal system from its 6,000-horsepower plant.

Electronic Computer Fights Storms. An electronic computer which will synthesize weather data in time to allow preventive measures to be taken against weather hazardous to airplanes was described by Doctor V. K. Zworykin (F '45) at a recent meeting of the Institute of Aeronautical Sciences in New York, N. Y. The computer is nearing completion at the Princeton, N. J., laboratories of the Radio Corporation of America where Doctor Zworykin is associate director of research. With the computer, he explained, a weather forecaster can recognize the beginnings of a hurricane in time to order oil spread and fired at a critical point, where it would dissipate the formation. Similar action can be taken by the spread of artificial white fog on the ground or at sea to create heat through reflection of the sun's rays; or by the spread of carbon black on either land or sea to absorb the rays and thus cool a critical point in the air mass, Doctor Zworykin said. He declared that, though the energies built up by storms are enormous, an insignificant amount of energy will set them off at points where they spend themselves harmlessly.

Loran for Maritime Commission. The Maritime Commission approved in January the purchase of 70 *DBS* loran receivers from the Navy Department as another step forward in greater navigational efficiency and safety at sea. A report by Captain J. F. Devlin, of the commission operations department, was influential in determining the decision of the commission to co-operate with the Army, Navy, and Coast Guard in developing loran equipment. Installation of 50 of the sets will be accomplished on board merchant vessels that are likely to continue in operation either under Government or private auspices. The remaining sets will be used in merchant marine training schools.

FCC Assigns High-Frequency Band. The Federal Communications Commission announced in December 1946, the assignment of the 2,400–2,500 megacycle band for immediate use for industrial, medical, and scientific purposes upon a nonexclusive basis. The order provides that apparatus employing this frequency band shall reduce radiated energy and band width to the greatest extent possible, so that no interference will be caused to authorized communications services from spurious or harmonic radiations. In the event of interference use of the equipment will be terminated until the necessary steps have been taken to assure proper operation.

French Electricity Restrictions. A new plan for electricity restrictions in France has begun, and from 7 a.m. to 7 p.m. consumers are to be deprived of service on two days a week except for a short period at midday for cooking purposes. Employers are discussing the effect the cuts are likely to have on industry, and it is possible that the working week will have to be cut to four days. Easing of restrictions is dependent on rainfall because the hydroelectric reservoirs are only half full. Official forecasts see cuts each year until 1950 when sufficient hydroelectric firm capacity will be available.

INDUSTRY

Two Million New Customers for Electrical Utilities

Nearly two million new customers were added to the lists of the electrical utility companies in 1946, even with the obstacles of equipment procurement difficulties and the housing shortage. An additional 60,000 applications for service were left unfilled at the end of the year because of material shortages and unavailability of skilled labor.

During the year the average residential consumption of electricity increased 100 kilowatt-hours, which set a record high average of 1,330 kilowatt-hours per consumer. At the same time the price of electricity declined, and the 1946 drop of four per cent in the cost of gas and electricity represents the greatest number of rate reductions in recent years.

Most of the new customers added in 1946 were in rural areas, with less than 400,000 of them within city limits. With 500,000 farms linked to service lines during the year, about 63 per cent of all occupied farms, or more than three million farms, now are electrified. In 1947 it is expected that another 600,000 farms will be serviced.

Power production remained at approximately the same level as in 1945, and of the 1946 total, 143 billion kilowatt-hours were produced by steam, an increase of two and one half billion units over the previous year.

Plans of the electrical companies for the next three years include the addition of 8,500,000 kw in generating capacity, with a total of 2,400,000 kw being added in 1947 and 3,500,000 kw in 1948. About 1,750,000 kw already have been ordered for 1949.

British Radar Expert Forms Company. Sir Robert Watson-Watt, prominent in radar research and development during World War II, has retired from his appointments in the British Air Ministry and the Ministry of Aircraft Production. He is forming a private company that will give technical advice to A. C. Cossor, Ltd., in England, and Sylvania Electric Products, Inc., New York, N. Y. The new company also will advise J. Arthur Rank's film organization.

Jet-Propulsion Engines Shown in London

These two engines are among those recently displayed at an exhibition of jet-propulsion engines and gas turbines held in London, England. Only engines which had passed through the experimental stage were shown with accompanying charts which described how the final designs were evolved

AT & T Observes 20th Year of Overseas Telphone

The 20th anniversary of the opening of the first overseas radiotelephone circuit, a single talking channel between New York and London, on January 27, 1927, was celebrated last month by the American Telephone and Telegraph Company, New York, N. Y.

An hour's rapid exchange of greetings and comment between New York, London, Frankfort on the Main, Buenos Aires, and Honolulu marked the anniversary. William G. Thompson, assistant vice-president of the American Telephone Company, first exchanged greetings with Hugh Townshend, director of communications of the British Post Office, London, England, at 10:09. Then until 11:19 newspapermen, telephone executives, and guests, assembled in the overseas room of the company's long lines building, participated in or listened in on the round of calls. Army officers in Germany testified to the usefulness of the transatlantic telephone. A Honolulu telephone man recalled that on the first day's operation of the single radio channel to Honolulu 15 years ago, only three calls were made. Six 2-way channels now handle an average of 250 daily calls.

It also was brought out that the New York–London and San Francisco–Honolulu circuits now are the world's busiest and that the entire system now reaches nearly 60 countries. The first greetings on the London–New York circuit in 1927 were exchanged between W. S. Gifford (A '16) president of the American Telephone Company, and Sir G. Evelyn Murray, secretary general of the British Post Office. The first commercial call was between Adolph S. Ochs, late publisher of the New York *Times* and Geoffrey Dawson, editor of the *Times* of London. The toll on such calls has fallen from $75 in 1927 to the present $12 on weekdays and $9 on Sundays and holidays.

RMA Asks Lower Radio Duties in New Reciprocal Trade Pacts

In anticipation of reciprocal trade agreement negotiations to be undertaken by the United States State Department with 18 countries in April, the Radio Manufacturers Association has asked that trade barriers in the countries concerned be withdrawn or reduced to the point where radio manufacturers in the United States will be able to compete in their markets.

The RMA made known its position in a brief filed with the United States Committee for Reciprocity Information. Stating that exports have become an important part of the radio industry, the RMA brief revealed that the total value of exports in radio equipment and components by all United States manufacturers for the first nine months of 1946 was $32,901,471.

The countries involved in the conference on tariff reductions to be opened in Geneva, Switzerland, April 8 are: Australia, Belgium, Brazil, Canada, Chile, China, Cuba, Czechoslovakia, France, India, Lebanon, (Syro-Lebanese Customs Union) Luxembourg, Netherlands, New Zealand, Norway, Union of South Africa, Union of Soviet Socialist Republics, United Kingdom, and the colonies of these nations.

Communication Industry Recapitulates 1946 Advances

A record year, in the number of persons served, plants built, and technological developments introduced, was reported by major communication companies for 1946, recently in the New York *Times*.

The American Telephone and Telegraph Company, New York, N. Y., introduced mobile telephone service, rural telephone service over electric power lines, rural radiotelephone service for remote farms and ranches, and intercity transmission of television over coaxial cables.

Bell System companies connected five million new telephones in the first ten months of the year, bringing the total of telephones in service in the United States, including the 6,000 of independent companies, over the 30-million mark. In addition, the Bell Company carried into 1947 a backlog of two million applications for service.

More than 500 million dollars worth of debentures and common stock was sold by the American Telephone Company in an unprecedented program of expansion financing.

The International Telephone and Telegraph Corporation, New York, through its affiliates, initiated direct high-speed radiotelegraph service between New York and Rome, Italy, and arranged for distribution in foreign countries of facsimile and telephoto products. The company also inaugurated a method of simultaneous transmission, over a single radio frequency, of eight separate radiobroadcast programs by means of pulse time modulation.

The Western Union Telegraph Company, New York, reported that construction of the first triangular radio beam telegraph system, to connect New York, Pittsburgh, Pa., and Washington, D. C., was well under way and expected to be completed early in 1947.

New Frequency Modulation Station. Approval has been given by the Federal Communications Commission for the erection of a 50-kw frequency modulation transmitter at the San Bruno, Calif., plant of Eitel-McCullough, Inc. Later in the year the transmitter will be moved to the 3,848-foot top of Mount Diablo, approximately 30 air line miles from San Francisco. Mount Diablo is unique in its command of large areas of territory, and with a single relay station on the Tehachapi range, network connections can be established with Los Angles, 420 miles to the south.

United States Sues Four Cable Manufacturers

The General Electric Company, the General Cable Corporation, the Okonite-Callender Cable Company, and the Phelps Dodge Copper Products Corporation were accused of violating the antitrust law in a civil suit filed January 29 by the Department of Justice in the Federal court in New York, N. Y.

It is claimed that the companies conspired to monopolize and restrain trade in the high-voltage electrical cable industry. The complaint, relating specifically to fluid-filled cable, charges the defendants with:

1. Creating an illegal patent pool.
2. Entering into cartel agreements, dividing the world markets with the principal foreign producers.
3. Fixing uniform prices in the United States.
4. Buying up, to the exclusion of all other companies all patent rights.
5. Suppressing commercial exploitation in the United States of a superior and more economical type of gas-filled cable which has been used widely abroad.

Also named as coconspirators, but not as defendants, were Societa Italiana Pirelli of Italy and Compagnie Internationale Pirelli of Belgium.

The suit seeks cancellation of the alleged illegal agreements and a decree that the defendants have used their patents unlawfully.

Lighting Awards Announced. A competition for $1,200 in merit awards, for outstanding examples of "What Planned Lighting Can Do" in industrial, store, and office applications and in floodlighting and street lighting, has been announced by the operating committee of the Second International Lighting Exposition to be held in Chicago, Ill., November 3–7, 1947. Entries are to cover reports and data on the results of planned lighting installations made during the calendar years of 1946 and 1947. All entries accepted by the board of judges will be placed on view at the exposition, and given an award of merit. In addition three cash prizes of $100 each will be given to the best entries from each of four classifications: electrical contractors, utility lighting representatives, architects and consulting engineers, and wholesaler's lighting specialists and salesmen. The deadline for entries is August 31, 1947, and entry blanks may be obtained from: International Lighting Exposition Award, Suite 818, 326 West Madison Street, Chicago, Ill.

Electrical Goods for Latin America. The Council for Inter-American Co-operation, Inc., New York, N. Y., reports that 20 per cent of all trade inquiries received from Latin America are requests for industrial machinery. Of the latter, 11 per cent are for electric equipment, with radios, refrigerators, power generating equipment, and motion picture apparatus ranking in that order in importance.

NEMA Attacks Secondary Boycott. Declaring that the electrical manufacturing industry has been victimized by secondary boycotts for 12 years, R. Stafford Edwards, president of the National Electrical Manufacturers Association, in a recent statement called upon Congress to outlaw all forms of the secondary boycott. The Edwards statement endorsed President Truman's assertion in his recent message to Congress that the secondary boycott is "an unjustifiable practice." In part, Mr. Edwards said: "What has existed in the electrical industry for 12 years is nothing more or less than a carefully organized and executed boycott by one union to maintain a complete nation-wide monopoly on the manufacture, distribution, transportation, and installation of electrical products. Through the use of identifying labels on the products made by its members, this union boycotts all products manufactured by employees who have exercised their rights under the Wagner Act to affiliate with another union or with no union." On the grounds that this is restraint of trade, Mr. Edwards suggested that remedy could be found in the injunction procedures, damages, and penalties now in the Clayton Act, and by loss of rights under the Wagner Act.

New 100,000-Kw Generating Unit. The Public Service Electric and Gas Company of New Jersey has authorized construction of a third 100,000-kw generating unit at its new Sewaren generating station to meet the peak load forecast for 1950. Construction is now under way on the initial two 100,000-kw units that are scheduled to be in operation by the fall of 1948. Design of all three units is similar. Each of the 100,000-kw tandem compound turbogenerators will be supplied with steam at 1,500 pounds per square inch and 1,050 degrees Fahrenheit by individual semioutdoor type boilers capable of evaporating 450 tons of water per hour.

Electrical Employees Increase. According to the New York State Labor Department electrical machinery firms in that state added 3,100 workers to their rolls during the months of October and November in 1946. Other industries showed corresponding increases.

Motors for Grand Coulee Pumps. The United States Bureau of Reclamation has ordered four of the twelve 65,000-horsepower a-c motors, to be used for pumping water from Roosevelt Lake formed by the Grand Coulee dam to irrigate the semiarid regions of south central Washington, from the Westinghouse Electric Corporation, East Pittsburgh, Pa. Each of the pumps will force over 600,000 gallons of water per minute through an 850-foot canal to the irrigation reservoir. Power for the 12 motors will be supplied by six 108,000-kw water-wheel generators which will be used for pumping purposes during off-peak load periods. Total weight of each motor will be 325 tons with a 172-ton rotor. The motors will operate totally enclosed at 200 rpm, and cooling will be accomplished by water-cooled recirculated air.

RESEARCH • • • • •

Ionosphere Research Aided. A comprehensive picture of propagation conditions in the 28-megacycle band is assured to the Central Propagation Laboratory of the National Bureau of Standards by the co-operation of 130 radio amateurs located in the United States, Canada, England, the Netherlands, Adak Island, Hawaii, and the Malay States. The program, established with the help of the American Radio Relay League, has as its primary purpose the collection of data concerning sporadic E-layer ionization which is often of such magnitude that excellent radio communication is possible, by means of reflection from the intensely ionized patches, at frequencies higher than will be reflected from the regular *E* and *F* layers of the ionosphere. Data sheets, provided to the "hams" by the laboratory, are returned to the Bureau of Standards monthly where the information becomes an integral part of research records.

X-Ray Absorption Measurement. H. E. Seeman and L. L. MacGillivray of the Eastman Kodak Company, Rochester, N. Y., research laboratories have developed a method for reducing errors caused by scattered radiation in photographic X-ray absorption measurements which are useful in calibrating X-ray machines and analyzing X radiation. Normally attempts to record absorption data with a single photographic exposure, which promotes accuracy in relative absorption measurements, involve the use of "stairs" of different thicknesses of filter material placed directly over the film holder. To overcome the scattering of radiation in this method, the researchers used a lead chamber consisting of several parallel longitudinal compartments. At the end of the chamber where X rays entered the compartments, holes were made over which filters were placed, and at the opposite end provision was made for the recording film.

Cyclotron for University of Rochester. A 1,200-ton cyclotron, second largest in the world, is being installed at the University of Rochester, N. Y., under the sponsorship of the United States Navy Office of Research and Invention. Construction and operation of the machine for basic research in nuclear physics is under the direction of the university's physics department, which is headed by Doctor George B. Collins.

EDUCATION . . .

Fellowship Deadline, March 15. Applications for the Westinghouse Educational Foundation Fellowship in electric power systems engineering, effective September 22, 1947, are being accepted at Illinois Institute of Technology, Chicago, Dean William A. Lewis (F '45) of the graduate school, has announced. All applications must be in before March 15, 1947. Established in 1945, the fellowship provides free tuition for a three-semester period of study as well as an additional grant of $500 each semester. The program consists of a prescribed course of study, including research and actual work in power system studies being made by the power and manufacturing companies co-operating on the institute's a-c network calculator. Satisfactory completion of the course leads to the degree of master of science in electrical engineering. Selection of fellows will be based on personal qualifications and interest, as well as on scholastic ability. All candidates must have a bachelor of science degree in electrical engineering from an accredited engineering college. Application blanks and further information may be obtained from the Dean of the Graduate School, Illinois Institute of Technology, 3300 Federal Street, Chicago 16, Ill.

GE Fellowships for Teachers Extended. Case School of Applied Science, Cleveland, Ohio, will offer 50 fellowships to high school teachers of physics for a 6-week program of study during the summer of 1947. Sponsored by the General Electric Company, the program at the Case School represents the extension to the Central States of a similar course of study which has been conducted for the past two years at Union College, Schenectady, N. Y., for teachers in the Northeastern States. The fellowships, designed to acquaint teachers with recent scientific developments, are available to teachers in the states of Ohio, Michigan, Western Pennsylvania, West Virginia, Kentucky, Indiana, Illinois, Wisconsin, and Maryland. Among the courses offered will be: science and engineering in the control of environment, basic concepts of physics, and frontier problems in physics. Courses will be conducted by members of the electrical engineering and physics departments of the Case School, and supplementary lectures and demonstrations will be given by the staff of the General Electric Company. The fellowships provide all tuition fees, room and board, and travel expenses.

Illinois Institute Fellowships. A general announcement of fellowships, scholarships, and assistantships, which are being offered for the term commencing September 22, 1947, has been made by the Illinois Institute of Technology, Chicago. All applications must be submitted to the Dean of the Graduate School, Illinois Institute of Technology, 3300 Federal Street, Chicago 16, Ill., by March 15, 1947. Among the fellowships which permit advanced study leading to either a master of science or a doctor of philosophy degree are: the Illinois Institute of Technology Research Fellowships, the Universal Oil Products Fellowship in Chemistry, the Institute of Gas Technology Fellowships, and the Armour Research Foundation Industrial Research Fellowships. The basic requirement for all fellowships is a bachelor of science degree from an accredited college. Scholarships covering tuition are offered by the institute to exceptional students who desire a full-time program of graduate study. Teaching assistantships are available in all departments of the college. In addition to the teaching positions, the institute has available certain research assistantships in connection with sponsored research projects.

Engineering Courses Revised To Add Humanistic Studies

Higher entrance requirements and a general revision of their engineering curricula, so that more time can be allotted to humanistic studies, have been announced by the State University of Iowa, Iowa City, and Lafayette College, Easton, Pa. The changes are in accord with recommendations of the American Society for Engineering Education.

Freshmen entering the University of Iowa school of engineering after June 1947 will be required to present college algebra, trigonometry, English composition and speech, and inorganic chemistry, which is expected to mean that most students will need at least one semester of work at a liberal arts or junior college after graduation from high school.

The revised engineering course at the university will include a total of about 25 hours of work in humanities and other nontechnical fields. Courses now planned are in English, speech, history of engineering, technical writing, economics, and political and social science.

At Lafayette College, algebra and trigonometry, usually included in the first semester program, will be taken in summer school prior to college entrance, and analytic geometry will be given during the first term instead. Certain survey and shop courses also no longer will be required.

HONORS . . . . . .

Kennedy Medal to Lorne Campbell. Award of the Sir John Kennedy Medal, senior award of the Engineering Institute of Canada, to Lorne Argyle Campbell, president and managing director of the West Kootenay Power and Light Company, Traill, British Columbia, has been announced. Established in 1927, the medal recognizes outstanding merit in the professions, noteworthy contributions to the science of engineering or to the institute "in commemoration of the great services rendered to the development of Canada, to engineering science, and to the profession by the late Sir John Kennedy, past president of the Institute." Mr. Campbell was born in 1871 in Ontario and was graduated from the Collegiate Institute of Perth. He was associated with the Canadian General Electric Company before joining the West Kootenay Company in 1898. He was elected to the British Columbia legislature in 1912, and was minister of mines in the provincial cabinet in 1916.

JOINT ACTIVITIES

Engineering Library Raises Rates for Special Services

To bring its prices into line with current costs, the Engineering Societies Library has increased the rates for searches and translations. The library will continue to provide these services at cost, as well as photographic and microfilm copies of material. The price for the latter service remains unchanged.

The new rates charged per hundred words for English translations of technical articles of ordinary difficulty are:

German, French, Italian, Spanish	$1.50
Russian, Polish, Dutch, Portuguese, Danish, Swedish	2.00

The rate for the translation of Japanese and Chinese remains at $3 per hundred words.

A small additional charge will be made for the extra time required for articles that contain a high proportion of formulas or other difficult material. The cost of any translation will be estimated if requested, but time can be saved if persons making inquiries will state the amount they are willing to pay. If this is sufficient to cover the cost, the work of translating can begin at once. The charge will be the same whether or not an estimate is supplied, as the work is done at cost.

Rates for searches have been increased from $2.50 to $3 per hour. The service bureau handles questions on any engineering subject that can be answered by consulting the existing technical literature. This service ranges from recommending books on a specific subject to the preparation of comprehensive annotated bibliographies. The original publication, if available in the library, is examined and is listed only if it is pertinent to the search. Literature searches are made for all purposes, including that of disclosures related to patents.

Searches are undertaken to suit the exact specification of the inquirer. To do this the searchers must know:

1. The subject, stated as exactly as possible with indication of those phases to be included and those, if any, to be excluded. Should the subject be covered very thoroughly, or will a less complete search suffice?

2. Period of time to be covered.

3. Is the search to cover materials in all languages or only in English? Is it to be restricted to material from any country or countries?

On request, the cost of covering a given field for a given period will be estimated, if the nature of the search makes this possible. A charge is made only for the time used.

Photostatic copies of material in the library can be supplied at the current rate of 30 cents a print. This price is for 11 by 14 inch, white on black (negative) prints. Any two facing pages which together measure not over 11 by 14 inches can be taken on one print. Larger material will require one print per page. Black on white (positive) prints cost an additional 30 cents each. Reductions or enlargements can be supplied.

Microfilm is economical for copying long articles; photostating is generally preferable for short ones. As most technical articles are short, the library does not have equipment for microfilm copying, but by arrangement with another organization, the library can supply microfilm copies of its material. Any one article from a magazine can be supplied for $1.50, regardless of the length of the article.

As all services are rendered at cost, payment in advance is requested when the exact cost of the work is known. Invoices will be sent when payment in advance is impracticable. The discount of 20 per cent on searches and translations, granted to members of the Founder Societies who order work for their personal use and pay by personal check, continues in effect.

Engineers Joint Council Adopts ASCE Labor Policy

The Engineers Joint Council, which represents approximately 100,000 engineers, will present a united front for the engineering profession before the 80th Congress in seeking labor legislation changes based on the policy adopted by the American Society of Civil Engineers in October 1946.

The policy was adopted in December 1946 by the Engineers Joint Council as representing "the consensus of the membership of the five constituent societies of the Engineers Joint Council," and recommended that the presidents of the constituent societies each appoint one of their members to the panel to confront Congress. In addition to the five constituent societies, the American Society for Engineering Education and National Society of Professional Engineers have been invited to appoint one representative each.

Directory of Corrosion Workers. The American Co-ordinating Committee on Corrosion has announced that it plans to revise its confidential directory of technologists actively engaged in studies on corrosion and its prevention. The directory currently lists some 500 investigators in a diversity of specialized fields selected on the basis of questionnaires circulated to the membership of the committee's member societies. The committee comprises delegates from 17 major technical societies, of which the AIEE is one, together with representatives from the principal industrial research institutes and other organizations, such as the National Bureau of Standards. Though the directory is reasonably complete, the committee believes that there undoubtedly are persons who were not reached in the previous circulations. Accordingly, the committee now requests all persons actively engaged in corrosion researches, who have not been contacted, to write the secretary, Professor Hugh J. McDonald, Illinois Institute of Technology, Technology Center, Chicago 16, Ill., for further details and application forms for directory listings.

OTHER SOCIETIES •

Radio Engineers Hold 1947 National Convention

The 1947 national convention of the Institute of Radio Engineers will be held in New York, N. Y., March 3–6, and the Radio Engineering Show will be held concurrently in Grand Central Palace.

The technical program has been expanded over previous years and a long list of papers will be presented. The 24 technical sessions will include presentations of papers on television, frequency modulation reception, navigational aids, electronic digital computers, electronic controls, measuring equipment, basic electronic research, vacuum tubes, circuit theory, communications systems, microwave equipment, and antennas.

Social events at the meeting will include the president's luncheon, the annual IRE banquet, and a cocktail party. There also will be meetings of the various institute committees during the convention.

Research Association "Proceedings." The Engineering College Research Association has announced the availability of the "Proceedings" of the 1946 annual meeting in St. Louis, Mo., in June 1946. Since January 1947, the Association has been the Engineering College Research Council of the American Society for Engineering Education. Included in the contents is a symposium of six papers on "Factual Experiences Dealing With Overhead Charges on Sponsored Research in Colleges of Engineering and the Bases Used in Calculating Such Charges" by research directors of six engineering schools. Two other papers, "Needs for Engineering Biographies" by Dean N. W. Dougherty of the University of Tennessee and "Training of Research Engineers" by Doctor J. R. Van Pelt of Battelle Memorial Institute, and a complete record of the activities of the association from 1944 to 1946 also appear in the 76-page publication. Price of the volume is $1.

Future Meetings of Other Societies

American Chemical Society. 111th national meeting, April 14–18, 1947, Atlantic City, N. J.

American Institute of Mining and Metallurgical Engineers. Annual meeting, March 17–22, 1947, New York, N. Y.

American Society for Engineering Education. 55th annual meeting, June 18–21, 1947, Minneapolis, Minn.

American Society for Testing Materials. 50th annual meeting, June 16–20, 1947, Atlantic City, N. J.

American Society of Mechanical Engineers. Spring meeting, March 2–5, 1947, Tulsa, Okla.; semiannual meeting, June 16–20, 1947, Chicago, Ill.; fall meeting, September 1–4, 1947, Salt Lake City, Utah.

American Society of Tool Engineers. Annual convention, March 19–22, 1947, Houston, Tex.

American Welding Society. Annual meeting, October 20–24, 1947, Chicago, Ill.

Canadian Electrical Association. Western conference, March 3–5, 1947, Vancouver, B. C.; 57th annual convention, June 18–20, 1947, St. Andrews, N. B.

Edison Electric Institute. June 2–5, 1947, Atlantic City, N. J.

Illuminating Engineering Society. East central regional conference, May 8–9, 1947, Washington, D. C.; Midwestern regional conference, May 15–16, 1947, Kansas City, Mo.; annual convention, September 15–19, 1947, New Orleans, La.

Institute of the Aeronautical Sciences. Aircraft propulsion meeting, March 28, 1947, Cleveland, Ohio; light aircraft meeting, May 26–27, 1947, Detroit, Mich.

Institute of Radio Engineers. Annual meeting, March 3–7, 1947, New York, N. Y.

International Lighting Exposition and Conference. November 3–7, 1947, Chicago, Ill.

Midwest Power Conference. March 31–April 2, 1947, Chicago, Ill.

National Association of Corrosion Engineers. April 7–10, 1947, Chicago, Ill.

National Electrical Manufacturers Association. March 3–7, 1947, Chicago, Ill.; October 27–31 1947, Atlantic City, N. J.

National Electrical Wholesalers Association. May 5–9, 1947, Atlantic City, N. J.

National Electronics Conference. November 3–5, 1947, Chicago, Ill.

National Fire Protection Association. 51st annual meeting, May 26–29, 1947, Chicago, Ill.

National Plastics Exposition. May 5–11, 1947, Chicago, Ill.

National Safety Congress and Exposition. October 6–10, 1947, Chicago, Ill.

New England Radio Engineers. May 17, 1947, Cambridge, Mass.

Pacific Chemical Exposition. October 21–28, 1947, San Francisco, Calif.

Refrigeration Equipment Manufacturers Association. All-Industry Refrigerating and Air-Conditioning Exposition. January 26–29, 1948, Cleveland, Ohio.

Rural Electrification Administration. National convention, April 22–25, 1947, Spokane, Wash.

Society of Motion Picture Engineers. 61st semiannual convention, April 21–25, 1947. Chicago, Ill.

Society of Naval Architects and Marine Engineers. Spring meeting, May 23–24, 1947, Washington, D. C.

$2,000 in Prizes Offered for Resistance Welding Papers

A total of $2,000 in cash prizes will be awarded in 1947 by the Resistance Welder Manufacturers' Association for outstanding papers dealing with resistance welding subjects. Wide choice in subject matter is allowed in order to assure eligibility to all papers which cover worth-while and significant information on theory and practice. Contest judges will be appointed by the American Welding Society, and awards will be made at the 1947 annual meeting of the society in October. The contest will close July 31, 1947.

One prize of $750 will be awarded for the best paper emanating from an industrial source, consulting engineer, private or government laboratory, or the like, the subject matter of which is concerned specifically with resistance welding. A prize of $500 is offered for the second best paper from an industrial source, and a prize of $250 for the third best paper.

A $300 prize will be awarded for the best paper from a university source—that is, either an instructor, student, or research fellow—which in the opinion of the board of awards is the greatest original contribution to the advancement and use of resistance welding. There will be a prize of $200 for the second best paper from a university source.

The minimum length requirement for papers entered is 2,500 words. Papers entered in the contest should be sent to American Welding Society, 33 West 39th Street, New York 18, N. Y. If mailed to arrive not later than July 1, 1947, three copies should be furnished. If mailed to arrive between July 1, and July 31, 1947, six copies should be furnished.

Chemical Society President. Election of Doctor Charles A. Thomas, vice-president and project director of the Clinton Laboratories in the Oak Ridge, Tenn., atomic bomb project, as president of the American Chemical Society for 1948 has been announced. Doctor Thomas, who also is vice-president of the Monsanto Chemical Company, St. Louis, Mo., became president-elect on January 1.

Engineering Society of Detroit Has Active Civic Affairs Committee

The Civic Affairs Committee of the Engineering Society of Detroit recently published its objectives which are:

1. To keep the society's membership informed with respect to broad and important public problems that confront the local community and that lend themselves to an engineering approach or solution.

2. To stimulate greater interest among local engineers in such problems so that as citizens they will take a more active part in their solution.

3. To assist public officials in the evaluation and solution of these problems.

4. On special occasions to give the public the benefit of the engineers' views, opinions, and advice concerning public problems on which the engineer is qualified to speak.

Among the various projects and problems which the Detroit society is considering are: airports, transportation, regional planning, smoke abatement, noise abatement, sanitation, parking, and public finance.

Optical Standards. At a recent meeting in New York, N. Y., representatives of 19 trade and technical societies, individual companies, and the Army and Navy took the first steps to set up a standardization project in the optical field under the auspices of the American Standards Association and sponsored by the Optical Society of America. Scope of the project is to include formulation of terminology, definitions, and standards; and the establishment of methods of testing, rating, and classifying characteristics of materials and devices used in optics. Among the wide variety of optical materials and devices which would come under the study of the project are filters, mirrors, lenses, mountings, physical detectors, spectrographic equipment, and general optical instruments.

New York Chapter of Tau Beta Pi. Members of Mu Alpha Omicron, honor society of Cooper Union School of Engineering, New York, N. Y., were inducted into Tau Beta Pi, national honorary society for engineers, January 11, 1947, in New York, N. Y. With the induction cermonies, Mu Alpha Omicron officially became the New York Iota Chapter of Tau Beta Pi.

ACCL Elects Officers for 1947. The American Council of Commercial Laboratories, New York, N. Y., at its recent annual meeting elected the following officers for 1947:

President—H. L. Sherman, Skinner and Sherman, Inc., Boston, Mass.

Vice-President—F. B. Porter, Southwestern Laboratories, Fort Worth, Tex.

Treasurer—G. J. Esselen, Esselen Research Corporation, Boston, Mass.

Secretary—B. L. Oser, Food Research Laboratories, Inc., Long Island City, N. Y.

Executive Secretary—A. J. Nydick, New York, N. Y.

The executive committee elected to serve one year is:

R. R. Bowser, Bowser-Morner Testing Laboratories, Dayton, Ohio; R. W. Truesdail, Truesdail Laboratories, Inc., Los Angeles, Calif.; M. C. Wylie, Gulick-Henderson Company, Pittsburgh, Pa.; W. P. Putnam, the Detroit Testing Laboratory, Detroit, Mich.

The American Council of Commercial Laboratories is composed of 32 independent research and testing laboratories, with main laboratories and branch testing stations located in 80 industrial centers.

Apprenticeship Expansion Urged. At a recent meeting of the executive committee of the general committee on apprenticeship for the construction industry, contractors and unions were urged to develop all possible means to stimulate apprentice training. E. H. Herzberg, chairman of the apprenticeship committee of the National Electrical Contractors Association, was among those present. In a breakdown of the number of apprentices in the construction crafts there were over 13,000 in the electrical trade at the end of October 1946.

Robert Watson (left) tube engineer and Doctor Irving Langmuir, of the General Electric Company, compare modern lighthouse tube with reproduction of the original lamp (center) with which Thomas Edison demonstrated the "Edison Effect." The high-vacuum tube developed by Doctor Langmuir in 1912 appears on the right.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part ot to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Maximum Energy Product of Permanent Magnet Steels

To the Editor:

One of the quality criteria for permanent magnet steels is the so-called maximum energy product. A typical demagnetization curve is shown in Figure 1 where the magnetic induction B in gauss is plotted as function of the demagnetizing force $-H$ in oersteds. The product of corresponding values of B and H is called the energy product and its maximum usually is found by plotting a complete curve of $B \times H$ as function of B. For an approximate maximum value of this product the following process is used.

A line is drawn from the origin of coordinates to the intersection of horizontal and vertical lines through B_r, the remanent induction and H_c, the coercive force, respectively, and it intersects the demagnetization curve at a point where the product $B \times H$ has been found to be a maximum for many materials.

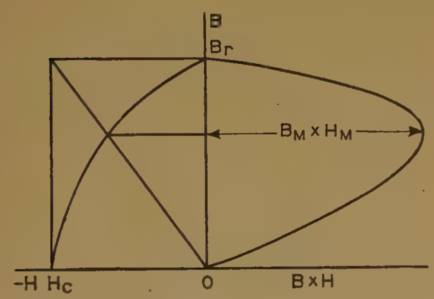


Figure 1. Demagnetization and B×H curves

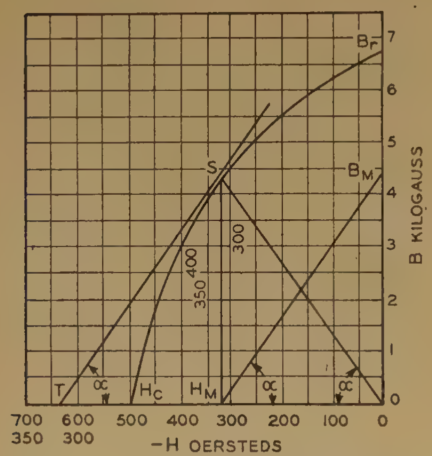


Figure 2. Graphical method for finding maximum of energy product

The following leads to an exact method for finding the maximum for any kind of material.

If we write $B = f(H)$, then the so-called energy product is given by $H \times f(H)$. If this product is to be a maximum, then the derivative $(d/dH)(H \times f(H))$ must equal zero, and we obtain the equation $f(H) + H(d/dH)f(H) = 0$ or rearranging $(d/dH)(H) = f(H)/-H$, but $(d/dH)f(H)$ is the tangent of the demagnetization curve as plotted, while $f(H)/-H$ is the tangent of the angle α in the congruent triangles $H_M O B_M$ and $H_M OS$. Therefore triangle OST is equilateral and $OT = 2OH_M$.

To find the point S of maximum value for $B \times H$ we proceed as follows.

On the H axis we ascribe to the points to the left of H_c their half values, for example, a point bearing by regular count the number 800 will be called 400. We furthermore write the H values alongside the demagnetization curve. We then lay a straight edge as tangent to the demagnetization curve and shift it along the curve while keeping it tangent. When the H value of the point of contact of curve and straight edge is the same as the half value of the intersection of the straight edge with the H axis, this then is the point sought and $H_m \times B_m$ is the maximum value of the so-called energy product.

It is evident that the same procedure can be carried out by using the B axis, as neither of the two axes has a preference.

Although of no great importance, it may be stated that it follows from the foregoing that the maximum of $B \times H$ never can be smaller than $B_r H_c/4$. It also follows that the approximate method mentioned before gives only correct values when the line drawn between the points H_c and B_r is parallel to the line ST.

LIONEL FLEISCHMANN
(Toledo, Ohio)

Energy Flow

To the Editor:

The "Electrical Essay for Recreation" presented in the January 1947 *ELECTRICAL ENGINEERING* by my friend Walther Richter illustrates very well the lack of unique meaning of the concept of electric energy flow. I tried to bring this out in my paper, "Energy Flow in Electric Systems—The *Vi* Energy Flow Postulate," in AIEE *TRANSACTIONS*, volume 61, 1942, pages 835–41.

The only requirement which an energy flow diagram must satisfy, and which is the *only* property defining it, is that the lines of flow must converge or end in proper amounts where electric energy is disappearing, that is at electric loads; and that lines of energy flow must diverge from or begin, in proper amounts, at points where electric energy is being created, that is at generators, batteries, and so forth. However, this requirement is not sufficient to determine uniquely the energy flow vector, and as I pointed out in the aforementioned paper, an infinite number of energy flow vectors may be defined or postulated, all differing from each other, and yet all equally valid in correctly portraying the sources and sinks of electric energy.

Of this infinite number of valid energy flow postulates, two are used widely; namely, the (usually incompletely given) *Vi* energy flow postulate of the electrical engineer; and the Poynting vector of the radio engineer and physicist. These two are quite different from each other. They place their respective energy flows at quite different locations in space, and even may give different answers to such questions as to which generator in an electric system is feeding which particular load. However, they will agree as to the magnitude of any load, or energy source.

I hope these remarks make it clear that the engineer inside Mr. Richter's compartments of his Figures 1 and 2 can know nothing whatsoever of the really observable and verifiable facts of energy flow outside his compartment. That is, he cannot, by any measurements he makes inside the compartment, know certainly that outside the compartment a load of certain magnitude is being fed by a source of like capacity. For example, friends of the engineer may play a trick on him and arrange the circuits external to the compartment as I have shown in my Figure 1. These friends arrange local circuits fed by small batteries to circulate the same intensities of currents in the wires in the compartment as in Mr. Richter's case, and they also energize these two local circuits relative to each other so as to produce the same potential difference between the wires as in Mr. Richter's case.

The engineer within the compartment then will get the same reading on his wattmeter as in Mr. Richter's case. How surprised he will be when he steps outside his compartment and finds that there is no load or source corresponding to his wattmeter reading.

The second example of Mr. Richter's is a very good illustration of the fact that the power engineer's *Vi* energy flow postulate is not universally valid, but needs enlargement or correction as I bring out in my paper referred to previously. In Mr. Richter's Figure 2, the simple *Vi* postulate fails. The enlarged, or corrected, *Vi* postulate becomes, in this case, identical with the Poynting vector; that is, it becomes an energy flow density given by $10/4\pi$ times the vector product of the

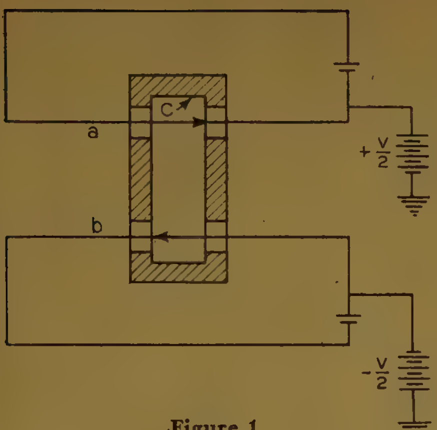


Figure 1

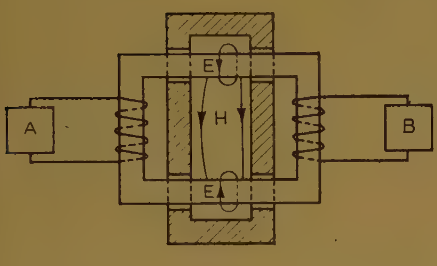


Figure 2

electric and magnetic fields. In my Figure 2, copy of Mr. Richter's Figure 2, I have added lines of magnetic force H, the leakage flux of the loaded transformer, and lines of the induced electric field, linking the cores of the transformer. It is clear that the vector product of these two fields will correspond to an energy flow proportional to the product of their magnitudes, which again will be proportional to the product of the load current and the induced volts per turn. Also this vector product will be directed parallel to the core pointing from Mr. Richter's source A to his load B.

J. SLEPIAN (F' 27)

(Associate director, research laboratories, Westinghouse Electric Corporation, East Pittsburgh, Pa.)

Electromagnetic Theory

To the Editor:

In response to your invitation, saying "Comments are invited" about "The Motional Mass of the Electron" by C. A. Boddie on page 45 of the January 1947 number, the following is submitted.

Any approach to subjects related to electromagnetic theory should be made with an attitude almost akin to reverence, but without fear. My life work has been along this line. One should not be too didactic and positive concerning any of the matters discussed. Therefore, I do not take sides with anyone in the controversy you have presented in the articles of Boddie and Sard. But I would like to present some thoughts that have a direct bearing upon these matters.

In 1917 I was employing the Lorentz form[1]* of electromagnetic theory, and published the fundamental force equation in the vector notation of Gibbs, as I received it from Professor Leigh Page of Yale in 1916, instead of using the x, y and z coordinates Professor Sard gives. The total mechanical force upon the first moving charge due to the second one is

$$\boldsymbol{F}=e_1\left(\boldsymbol{E}+\frac{1}{C}\,\boldsymbol{q}_1\times\boldsymbol{H}\right) \tag{1}$$

where

$$\boldsymbol{E}=\frac{e_2(1-\beta_2^2)}{R^3\left(1-\dfrac{\boldsymbol{q}_2\cdot\boldsymbol{R}}{CR}\right)^3}\times\left\{\boldsymbol{R}-\frac{R}{C}\boldsymbol{q}_2+\frac{\left\{\boldsymbol{f}_2\times\left(\boldsymbol{R}-\dfrac{R}{C}\boldsymbol{q}_2\right)\right\}\times\boldsymbol{R}}{C^2(1-\beta_2^2)}\right\} \tag{2}$$

and

$$\boldsymbol{H}=\frac{e_2(1-\beta_2^2)}{R^3\left(1-\dfrac{\boldsymbol{q}_2\cdot\boldsymbol{R}}{CR}\right)^3}\times\left\{-\frac{\boldsymbol{R}\times\boldsymbol{q}_2}{C}+\frac{\boldsymbol{R}\times\left\{\left[\boldsymbol{f}_2\times\left(\boldsymbol{R}-\dfrac{R}{C}\boldsymbol{q}_2\right)\right]\times\boldsymbol{R}\right\}}{RC^2(1-\beta_2^2)}\right\} \tag{3}$$

Here $\boldsymbol{R}$ denotes the variable vector from e_2 at time $t-R/c$ to e_1 on which the force is expressed at time t. Vector velocities are denoted by $\boldsymbol{q}$ and accelerations by $\boldsymbol{f}$, with the proper subscripts referring to the first and second electrons.

If we wish to find the total mechanical force upon the first charge when both the velocity and the acceleration of the second charge are zero, put both $\boldsymbol{q}_2$ and $\boldsymbol{f}_2$ equal to zero. The value of $\boldsymbol{H}$, the magnetic component, vanishes completely, and the value of $\boldsymbol{E}$, the electrical component reduces to

$$\boldsymbol{E}=\frac{e_2}{R^3}\boldsymbol{R} \tag{4}$$

Substituting in equation 1 the total mechanical force is

$$\boldsymbol{F}=\frac{e_1e_2}{R^3}\boldsymbol{R} \tag{5}$$

When the charges have the same sign, the force is positive denoting repulsion, because the positive direction of $\boldsymbol{R}$ is from e_2 to e_1. This is merely the electrostatic force.

The conclusion is that, since $\boldsymbol{q}_1$ does not appear in the expression for $\boldsymbol{E}$ in equation 2, the only way it can appear in the force is by means of the second or magnetic term of equation 1. But this is now out because $H=0$, so that the force upon e_1 is merely the electrostatic force, which is the same whether the first charge is moving or not.

This result seems to differ from Professor Sard's statement at the top of page 62, for he does not make this total force independent of the velocity of e_1 as we do.

The problem that I had set myself in the paper referred to was to find the average mechanical force that one rotating circle of charge exerts upon another rotating circle at a distance. This problem was first enunciated by Gauss in 1835, and was called by him the fundamental keystone of electrodynamics.

From the general equation 1–3, I obtained an expression for the instantaneous force in circular motion of the two charges in equations 48, 49, and 50 of that paper. One year later, 1918, the late Professor G. A. Schott carried this investigation further, and stated that he agreed[2] with my equations, 48, 49, and 50, and then obtained the exact average for the force acting along the line of centers. With this I am in agreement. He averaged both the electrical and the magnetic components, and discovered that the magnetic component averaged exactly to zero, the whole result depending solely upon the electrical component. His result is as follows.

$$\frac{\boldsymbol{F}\cdot\boldsymbol{r}}{r}=-\frac{e_1e_2}{r^2}\times\left\{1-\beta_2^2\left(\frac{1}{1-\beta_2^2}-\frac{1}{2\beta_2}\log\frac{1+\beta_2}{1-\beta_2}\right)\right\} \tag{6}$$

To simplify this we have

$$\frac{1}{2\beta_2}\log\frac{1+\beta_2}{1-\beta_2}=1+\frac{1}{3}\beta_2^2+\frac{1}{5}\beta_2^4+\frac{1}{7}\beta_2^6+\ldots \tag{7}$$

and

$$\frac{1}{1-\beta_2^2}=1+\beta_2^2+\beta_2^4+\beta_2^6+\ldots \tag{8}$$

and finally

$$\frac{\boldsymbol{F}\cdot\boldsymbol{r}}{r}=-\frac{e_1e_2}{r^2}\times\left(1+\frac{2}{3}\beta_2^4+\frac{4}{5}\beta_2^6+\frac{6}{7}\beta_2^8+\ldots\right) \tag{9}$$

The marked characteristic of those equations 48, 49, and 50 is that the speed of the first charge does not appear anywhere, so of course it could not appear in Schott's result (equation 9). We had both devoted a large amount of labor to this investigation, which might have been saved had we realized that any equation of this type, lacking the velocity of the first charge, must lead to a zero force when the forces are summed up for neutral atoms. This will be evident by the next example.

The next year, 1919, Megh Nad Saha published[3,4,5] a new expression for the force between two electrons based upon the 4-dimensional analysis of Minkowski, in which Saha assumed the four coordinates to be independent of each other, instead of dependent, as previous authors including Lorentz had been using them.

* Professor Sard interchanged the subscripts that Doctor Crehore had used making them e_2 instead of e_1, the charge upon which the force is exerted.

His investigation produced a new factor multiplied into the expression for the force, which contained the velocity of the first charge that is lacking in the Lorentz expression (equation 2).

It is most interesting that the factor introduced by Saha into the expression for the mechanical force of the second upon the first charge is exactly the same as the factor (see Mr. Boddie's equation 1), namely $(1-\beta_1^2)^{-1/2}$, which determines the change of mass of the electron with its velocity.

So, when we divide the force by the mass to obtain the acceleration according to the relation

$$F=ma$$

or

$$F/m=a. \tag{10}$$

or when e_1 is in motion,

$$\frac{F(1-\beta_1^2)^{-1/2}}{m_0(1-\beta_1^2)^{-1/2}}=\frac{F}{m_0}=a_1 \tag{11}$$

Thus the acceleration, or the motion, is not affected by the supposed increase of mass, but behaves as though the electron has its rest mass. This, I believe, touches upon the chief point that Mr. Boddie makes in his well-prepared paper, and confirms his contention from an angle that perhaps he did not expect. This factor of Saha's makes the force depend upon the velocity of the first charge under all circumstances, and it immediately rectified the grave error that has been present in electromagnetic theory for more than 30 years. To me it is unthinkable that the force upon the first electron due to the second one ever can be just the electrostatic force irrespective of its velocity, and I pointed this out in that 1917 paper.

In 1921 I used the Saha equation in the same manner the Lorentz equation had been employed before for two revolving circles. Briefly, the resulting average force from the Saha equation is

$$F_r=\frac{E_1E_2(1-\beta_2^2)}{kr^2(1-\beta_1^2)^{1/2}}\times\left[-1-\frac{1}{3}\beta_2^2-\frac{11}{60}\beta_2^4-\ldots\right] \tag{12}$$

The afore-mentioned new factor appears in the denominator of the coefficient. After expanding this radical into series and multiplying in, we have as the equivalent of equation 12 the total average force of the second on the first electron, considering each charge, positive and negative, as revolving circles—very small.

$$F_r=\frac{E_1E_2}{kr^2}\times\left[-1+\frac{2}{3}\beta_2^2-\frac{1}{2}\beta_1^2+\frac{3}{20}\beta_2^4+\frac{1}{3}\beta_1^2\beta_2^2-\frac{3}{8}\beta_1^4\ldots\right] \tag{13}$$

When an equation of the type of equation 9 from the Lorentz theory is summed up for all charges in a neutral atom, the resulting sum is exactly zero, but this is not true with equation 13 from the Saha theory. All terms vanish, however, in the process of summing except the term containing both velocities, the $\beta_1^2\beta_2^2$ term. For example, take the simple atom having a central charge of plus two units and two negative electrons. The force upon the one positive charge due to the second one according to equation 13 is

$$F_r=\frac{4e^2}{kr^2}\times\left[-1+\frac{2}{3}\beta_2^2-\frac{1}{2}\beta_1^2+\frac{3}{20}\beta_2^4+\frac{1}{3}\beta_1^2\beta_2^2-\frac{3}{8}\beta_1^4\ldots\right] \tag{14}$$

There being three charges in each of the two neutral atoms, there are nine forces in all, as there are nine pairs of charges. Equation 14 is one of these forces, and there are eight more, namely the forces due to the positive charge in atom number two upon the two electrons of atom number one, and those of the two electrons in the second atom acting upon the positive charge of the first atom, and so forth. It is not necessary to enumerate them all. In adding, the values of β applied to the negative electron are considered so small as to be quite negligible when compared with the betas that apply to the positive charges. Then all the terms in equation 14 except the $\beta_1^2\beta_2^2$ cancel out, giving the total average force between the two atoms at a distance as

$$F=\frac{4}{3}\frac{e^2}{kr^2}\beta_1^2\beta_2^2 \tag{15}$$

This force varies inversely as the square of the distance, and is always an attraction, and never a repulsion. It has been definitely identified with the force of gravitation, but this is not the place to discuss this subject. I have used the Saha theory ever since 1921, and find that it is free from the objections to the Lorentz theory which have been mentioned. I am in agreement with Mr. Boddie's statement on page 57 "that the universally accepted formula of Lorentz must be abandoned." But I have not been in that universal class for a number of years. The Institute is to be congratulated upon stressing this topic at the present time. I have certainly tried for years to bring to the attention of physicists the fact that the force upon one electron due to another is without exception dependent upon its velocity, but it has been difficult to overcome the inertia of the human mind.

REFERENCES

1. Some Applications of the Electromagnetic Equations to Matter, Supposed to Be Constituted of Positive and Negative Electrons, **A. C. Crehore.** *Physical Review,* volume 9 (second series), June 1917, page 448.

2. On the Supposed Gravitational Attraction Between Two Revolving Electrons, **G. A. Schott.** *Physical Review,* volume 12 (second series), July 1918, page 23.

3. On the Mechanical and Electrodynamical Properties of the Electron, **Megh Nad Saha.** *Physical Review,* volume 13 (second series), January 1919, page 41.

4. Electrons, Atoms, Molecules (book), **A. C. Crehore.** The Christopher Publishing House, Boston, Mass., 1946. Page 100.

5. Autobiography (book), **A. C. Crehore.** W. G. Berner, Publisher, Gates Mills, Ohio, 1944. Pages 134, 142.

A. C. CREHORE (A '92)

(Cleveland, Ohio)

Motional Mass of the Electron

To the Editor:

I want to congratulate you on the new publication policy for *ELECTRICAL ENGINEERING.* The article by C. A. Boddie (*EE, Jan '47, pp 45–60*) is of particular interest and makes sense. I am not enough of a mathematician to help him argue it out with the classical physicists, but I am certainly with him.

F. W. CHAPMAN (M'37)

(Superintendent, Utilities Department, Commissioners of Public Works, Greenwood, S. C.)

To the Editor:

This letter is written in response to the article, "The Motional Mass of the Electron," by C. A. Boddie, published in the January 1947 issue of *ELECTRICAL ENGINEERING.*

As pointed out in that article, a theory must stand or fall on its ability to explain observed phenomena. In actual practice, we expect more of a theory than a mere explaining away function. A satisfactory theory must have as a basis postulates which are themselves consistent with both observation and, to some extent, intuition (although intuition is notoriously defective in pointing the way in many instances). It is certain that once we have agreed on certain postulates, we must (if we are logical creatures) accept those conclusions which logically may be drawn from the postulates. As an aside here, we might note that a theory should not be scorned because it is couched in "the obscurity of pure mathematics." Mathematics is the foundation upon which the most fruitful results of man's thinking are raised.

Mr. Boddie has created a structure which purports to replace some current ideas in physics. We can be sure of one thing; that is, if his postulates (or assumptions) and reasoning are correct, recourse must be had to experiment to verify the results of the conclusions drawn from his postulates. Such experiments, for the region in which his theory might be tested, have yet to be made.

But an equally valid method of disposing of the Boddie theory is to show the presence of a vital flaw in the reasoning by which he arrives at his conclusions.

The italicized statement in the following two paragraphs quoted from Mr. Boddie's article is at fault:

"It long has been held by both classical theory and relativity theory that an electric field in motion is increased in intensity according to a formula exactly

analogous to the motional formula of Lorentz for electronic mass, that is

$$E_v=\frac{E_0}{\sqrt{1-v^2/C^2}} \tag{10}$$

where

E_0 = the intensity of an electric field at rest

E_v = the intensity of the field E_0 moving at velocity v

"Since, according to relativity, it is only relative motion that counts, *this equation applies equally to the case where the field is at rest and the test charge is in motion.* The denominator of this equation is in nature of a correction factor to correct the static field effect for relative motion."

Now, what is wrong with the statement we have italicized? Just this: because measurements made on a system in linear unaccelerated motion with respect to another system will fail to reveal such relative motion (one of Einstein's postulates, and hardly speculative, since it is in perfect accord with experience), it is perfectly valid, in determining the laws of nature, to consider either of the systems to be at rest; and to make all measurements with respect to the units of that system. In the present problem, this means that we can take either of two viewpoints; our apparatus is stationary and the electron is in motion, or the electron is stationary and the test setup is in motion. By the postulate given above, these points of view have equal merit, and the results in either case will be valid. But all measurements must be made with respect to the *same* system of reference! It is of course more convenient to suppose that we and our physical apparatus are motionless, and that the electron is in motion. Which we do. Now, the electric field between two plates shares the motion (if any) of those plates. Because the plates are stationary *with respect to our chosen frame of reference,* so is the electric field. *We cannot introduce into our measurements a value which "would have been found" had we considered the electron to be at rest* and the rest of the system in motion, for not only would the electric field value be different, but so would other measurements in the calculation (the length of the path traveled by the electron from the deflection plates to the screen, for example). Such a measurement is not consistent with the other measurements in our chosen frame of reference.

The equation

$$E_v=\frac{E_0}{\sqrt{1-v^2/C^2}}$$

therefore is not applicable to our chosen co-ordinate system, and no "correction factor" need be (nor should it be) applied to the equation

$$\frac{e}{m}=\frac{C^2}{r}\times\frac{E}{H^2}$$

hence the mass of an electron does increase with velocity in accordance with the relativity theory.

We do not intend to belabor the point further. It will of course be true that any conclusion drawn from a faulty premise will in itself be faulty.

JOHN F. SCULLY

(Staff engineer, Watson Laboratories, Red Bank, N.J.)

Sign of Reactive Power

To the Editor:

The November issue of *ELECTRICAL ENGINEERING* contained an AIEE subcommittee report recommending that the present standard for the sign of reactive power be changed. The report presented the reasons why the change is deemed necessary and stated that no corresponding reasons could be found favoring the retention of the present standard. I believe that the subcommittee has overlooked some pertinent reasons against the change and am presenting them.

WRONG POINT BEING STANDARDIZED

In the first place, the subcommittee has missed completely the point needing standardization. In the operation of a-c power systems, two quantities are necessary, energy and excitation. The energy (power) comes from the generators. Excitation comes from generators, condensers, and the capacitance of circuits. If the AIEE will revise American Standards Association definition 05.21.050 and standardize the var as the unit of excitation (or magnetization), there will be no need in system operations for it to have an algebraic sign any more than there is for the watt. There is no need for magnetizing vars flowing counter to the energy flow having a separate name any more than there is for watts when they flow first in one direction and then in the other in a transmission line. The conventional markings on center zero wattmeters is "IN" and "OUT" and this is all that is needed on varmeters, if the var is defined as the unit of magnetization. The confusion which now exists comes solely from the present usage wherein magnetizing vars flowing in the same direction as watts are called inductive reactive vars and magnetizing vars flowing counter to the flow of watts are called capacitive reactive vars. This is a holdover from the early days of the art

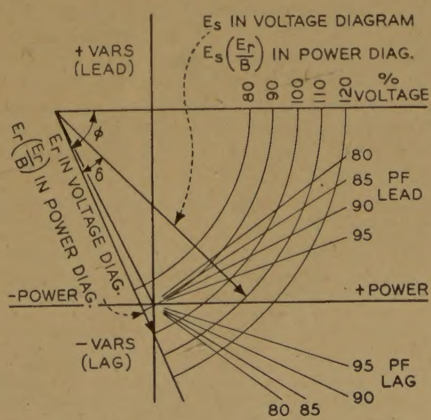


Figure 1

before there were transmission lines, and it should be eliminated. It certainly is not necessary to outlaw the conventional calculation methods which have been in use for so many years.

TEXTBOOKS OBSOLETE

A standard now exists and it is one which was established largely because of its general use in textbooks. All textbooks which treat the subject, in libraries available to the writer, use the present standard with one exception. The one exception was the texts of the Westinghouse training program which used the E conj I convention in developing power circle diagrams. Most of the texts were written before the formal adoption of the American Standard in 1941. A change now would result in confusion for many years to come.

TWO FORMS FOR CIRCLE DIAGRAMS

Transmission line performance is commonly calculated by means of the following equations:

$$E_s=E_rA+I_rB \tag{1}$$

$$E_r=E_sA-I_sB \tag{2}$$

By means of equation 1 a regulation chart can be obtained as shown in Figure 1. This diagram had been plotted to rectangular co-ordinates having the power axis horizontal. Figure 1 will be recognized as being identical with a power circle diagram drawn for E_r constant by means of the following equation:

$$P_r+jQ_r=-E_r^2\frac{(a_1b_1+a_2b_2)}{B^2}+jE_r^2\frac{(a_1b_2-a_2b_1)}{B^2}+\frac{E_rE_s}{B}(\cos(\phi-\delta)+j\sin(\phi-\delta)) \tag{3}$$

where R, X, Z, A, B, a_1, b_1, a_2, b_2 are systems constants, ϕ = impedance angle $\tan^{-1} X/R$ and δ = angle between E_s and E_r. The power circle diagram is therefore a regulation diagram and should conform to regulation diagrams as regards power factors and rotation of vectors. This is the case with the existing standard. With the standard proposed, the diagram would appear as in Figure 2. Lagging vars appear as a plus j quantity but vectors representing voltage displace clockwise, E_s from E_r, and the only way to duplicate this diagram by means of equation 1 is to use clockwise rotation and the $R-jX$ convention. How does the subcommittee propose to reconcile the diagrams of Figure 1 and Figure 2? It certainly is not desirable to recognize as standard, both clockwise and counterclockwise displacement of E_s from E_r.

METHOD USED TO DETERMINE SIGN QUESTIONED

The method for determining the sign of reactive power used by the subcommittee

while using a true mathematical expression is not up to the usual high standard of the Institute. Any expression or equation in order to be used as a standard should be general, and in this case an equation used to express power should be capable of expressing the flow at any point in any circuit of any kind whether generator, load, or line. Equation 4, $P+jQ=I^2(R+jX)$ of the subcommittee report is a special case of losses in an impedance and is not general, since there is no possible manner in which an equation of the type of equation 3 of this discussion can be reduced to equation 4. By the use of equation 4, if the impedance is a transmission line, the identity of all currents is destroyed by squaring, and all currents of the same magnitude regardless of power factor yield the same results. The $R+jX$ convention was established to give the proper identity to current vectors by the use of Ohm's law and the proper signs for voltage drops. It should not be used to destroy identity. In addition, vector power in Figure 3 of the subcommittee report violates the AIEE rule for vectors in which the leading quantity should be displaced counterclockwise from the lagging quantity. If S is to be called vector power it must be able to represent volt-amperes and for lagging power factors must follow real power counterclockwise in its displacement. This should invalidate the subcommittee recommendation. It appears that the AIEE in developing a standard should be above using a mathematical trick as the criterion for obtaining a sign when a straightforward method based upon the relationship of current to voltage is available.

PRACTICAL REASONS GIVEN NOT JUSTIFICATION FOR CHANGE

The practical reasons for the change 1 to 6 listed on page 515 are practical in name only. Operating men will continue to meter energy and magnetizing vars delivered no matter what standard is adopted for the conjugate multiplication, and meters will continue to record properly just as they have in the past. Calling these quantities positive in speaking of them and then taking this as a reason for changing the standard for the sign of inductive reactive power is rather far fetched. Operating men never speak of positive real power and positive inductive reactive power. These are terms which in the past have appeared only in textbooks in connection with theoretical discussions of power. In these discussions negative power also is recognized, a term which never appears in operating usage. Reason 6 indicates that the subcommittee has not consulted many operating men in regard to current practices. The scheme they propose, wherein wattmeters deflect to the right on power delivered and varmeters do the same for magnetizing vars delivered, has been in use on probably the largest interconnected system since 1940 and is the same scheme described in the *Electrical World* of April 18, 1942, by G. S. Lunge. This system even marks the scales of its synchronous condensers "IN" and "OUT." "OUT" denotes vars

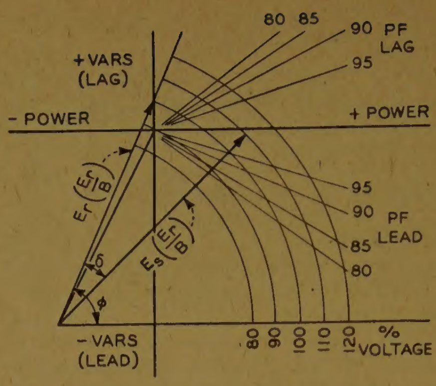


Figure 2

due to overexcitation. This is the same quantity which was marked "KVA LEAD" on condenser meters and "KVA LAG" on generator meters for so many years and still is on some of the meters at older plants. The subcommittee seems to be in a fair way to perpetuate this confusion by continuing to recognize positive and negative vars as separate system quantities.

The subcommittee preaches practical considerations rather than technical considerations, but practical methods will not be affected in any manner whatsoever by either retaining the present standard or changing it. Technical methods, however, would be the ones to suffer and would be thrown into utter confusion.

CONCLUSIONS

The subcommittee in its proposal that inductive reactive power be treated as a positive quantity in all vector power calculations in which current and voltage are multiplied and that the j sign of the reactive current component should be changed in such multiplications is doing the Institute and the profession a distinct disservice. If the change is adopted, it means:

1. Perpetuation of two types of vars as system quantities whereas present usage gradually is being changed to recognize only one type, those due to system excitation.

2. Practically all textbooks on the subject will be made obsolete.

3. Two vector displacements will be legalized, clockwise for vector power, counterclockwise for voltage and current vectors.

4. A method for determining the sign of reactive power is used which is not general, and has no relationship whatsoever to the power factor of the load at any given point. Such a method is not valid by best AIEE standards.

5. The fact that operating organizations treat energy and magnetizing vars as the quantities which they generate and dispose of is not a valid reason for proposing that the methods of calculating volt-amperes and real power be changed arbitrarily. Power systems do not use the terms positive power or positive vars in their operations.

V. J. CISSNA (M '30)

(Power engineering and construction department, Tennessee Valley Authority, Chattanooga, Tenn.)

To the Editor:

I advise against the proposed change.

The sign of inductive reactive power can be changed from negative to positive only if inductive reactance, $jX=j\omega L$, is considered negative. Proof is appended. To consider inductive reactance negative, and capacitive reactance positive, is contrary to generally accepted usage.

The change will not upset only the power engineers who are concerned with circuit analyses; also the thousands of communication and electronics engineers will be confused, for a matter in which they are primarily not interested. The power concept, broadly speaking, is immaterial to the communications man. So why upset him for a cause alien to him?

Finally, adoption of the proposed change will be contrary to the accepted International Electrotechnical Commission definitions. As a consequence, the confusion which already exists between United States and European units* will be increased. Is this desirable?

PROOF

The impedance Z of a series connection $R+jX$ is represented vectorially by the left-hand triangle (Figure 1).

The corresponding admittance Y, by the rules of plane vector algebra, is found by taking the reciprocal of $|Z|$ and plotting it under the angle $-\varphi$, with the plus axis as reference. The Cartesian components of Y are then $+G$ and $-jB$. If such a series connection is connected to a voltage E (E assumed to be in the direction of the plus axis) it draws a current $I=EY$ in phase with Y. The Cartesian current components are $+I_R$ and $-jI_X$. The apparent power is EI, with the active component $+EI_R$, and the reactive component $-jEI_X$.

The same result, obviously, is obtained when the equivalent parallel admittance $G-jB$ would have been selected from the start.

A 2-terminal box when connected to a source will draw the same current whether it contains R and X ohms in series, or G and B mhos in parallel. A wattmeter, varmeter, and power factor meter connected between source and load will indicate in both cases the same respective readings.

If the inductive load is replaced by a capacitive load, all signs of the imaginary components change. Consequently, while the wattmeter reading will remain the same, varmeter and power factor meter will reverse directions.

The point is that a positive inductive reactance, $+jX$, necessarily leads to a negative reactive power $-jEI_X$, and a capacitive reactance, $-jX$, to a positive

* United States horsepower = 746 watts, and European horsepower = 736 watts. Propagation constant here $\gamma=\alpha+j\beta$; over there, $\gamma=\beta+j\alpha$, to quote but two.

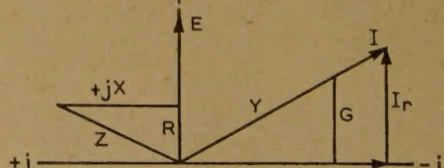


Figure 1

reactive power, $+jEI_X$. Hence, if one decides to ascribe to inductive reactive power the plus sign, one has no other choice but to designate an inductive series impedance by $R-jX$, and a capacitive series impedance by $R+jX$.

LUDWIG F. ROEHMANN (M '37)

(Research engineer, Anaconda Wire and Cable Company, Hastings-on-Hudson, N. Y.)

To the Editor:

The "AIEE Subcommittee Report on Sign of Reactive Power" is an able presentation of the reasons favoring a change in the sign. As one of the subcommittee members, I personally favored an unbiased presentation of both sides of the problem. To complete the record, the following reasons for not making the change in the sign of reactive power are listed briefly:

1. The American Standard should be in accord with the adopted International Standard (as it is at present and as it would not be after the change).

2. The most common vector diagrams in use for power circuits use the voltage vector as reference (since it is usually the most nearly constant quantity in voltage distribution systems) and shows lagging current (supplied to an inductive reactance) in a downward (negative) direction. The proposed change assigns a *positive* sign to inductive loads when considered as kva, and a *negative* sign to the same load when considered as amperes.

3. Changing conditions such as predominately capacitive loads would create a demand for a change back to the present definition.

Actually there is a third alternative, and that is not to assign a permanent sign to reactive kilovolt-amperes, but let the sign be given at will to fit the application. In most cases, it is convenient to give a positive sign to the quantity which occurs most frequently. This procedure has the advantage of avoiding expressions such as negative-positive reactive power, negative-negative reactive power, or positive-negative reactive power.

In this view, the giving of mathematical signs is left to the user of the mathematics without attempt to dictate to him what sign he will use. It is generally preferable to give names rather than mathematical signs to distinguish between quantities. One doesn't speak of negative (real) power and positive (real) power, except in mathematical terms. Generated power may be considered as either positive or negative power; power used may be considered either positive or negative. Why not distinguish between the two kinds of reactive power as inductive power and capacitive power, or other appropriate names and leave the mathematical terms positive and negative free for mathematical use?

It may be well to note that the principal reason given for a strongly biased report was that such a report would create discussion and interest while an unbiased report might not be given proper consideration. My personal preference is for the third alternative, since it is just as rigorous as the other two alternatives and possesses the advantages of both the others while eliminating some of their disadvantages.

W. C. SEALEY (M '38)

(Engineer in charge, transformer design, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.)

To the Editor:

The AIEE Standards committee (*EE, Nov '46, pp 512–16*), has been diligent in studying the problem of sign of reactive power and has offered six points in favor of a standard which would fix inductive vars as positive.

As pointed out by Doctor F. B. Silsbee (*EE, Dec '46, pp 598–9*); the committee's "presentation is accurate and shows conclusively that, although either convention is possible mathematically, the present standard is the one which yields a vector power diagram which is similar to the admittance diagram and which is therefore the more useful for handling problems involving many individual loads connected in parallel."

Students and engineers alike are quite accustomed to the idea of power factors in multiple or parallel circuits. In such a system the voltage is quite naturally the reference vector in which case the current vectors are shown to lag the voltage in inductive circuits and to lead the voltage for capacitive circuits.

Such a vector diagram can be converted to a volt-ampere chart by the simple process of multiplying all current vectors by the constant voltage. Such a chart would indicate power along the X axis and reactive vars along the Y axis, lagging vars automatically becoming negative in sign while leading vars would have a positive interpretation. The subcommittee proposal would deny the validity of this simple logical process with very dubious benefits resulting.

To present the point of view of the new proposal, the teacher must find some reasonable explanation to satisfy the students' curiosity. Of course he can tell the student that the common parallel system is to be converted into an equivalent series network with current as the reference vector. This procedure seems a little confusing.

To a college professor, who has been trying to teach the subject of transmission line behavior, the present standard, based upon the vector diagram of a parallel system, seems so simple that he can not fully appreciate the arguments of the subcommittee.

There should be no particular objections to lagging reactive having a $-j$ sign from a metering point of view because metering is concerned with the direction of flow and not with the sign of the j, and the $-j$ sign is no handicap to utility billing. Utilities probably would like to bill a customer for excessive leading vars if it involved the use of more installed capacity. Both types of vars have the objectionable quality of requiring excess installed equipment capacity.

Point 4 seems a little arbitrary. A transmission line delivering current to a capacitor located at the receiver end is subject to a power loss as well as when such a line supplies an inductive load.

Items 5 and 6 are concerned with the actions and points of views of the generating station. Power systems have many more substations than generating stations, and often power may be flowing in or out of such stations.

Much of our notation is based upon arbitrary rules or standards. A generator which operates under the influence of a leading power factor is said to deliver leading reactive vars. The leading reactive vars of such a generator conceivably can be defined as positive by the mere fact that it supplies a "positive" magnetizing effect. Conversely, lagging reactive vars would supply a demagnetizing or "negative" magnetizing effect.

A college professor is, possibly, not in a good position to pass judgment on the problems of the operating engineer, but he is nevertheless entrusted with the task of training the engineers of the future. In this light it is hoped that due consideration be given to some of the academic problems involved.

J. G. TARBOUX (F '43)

(Professor of electrical engineering, Cornell University, Ithaca, N. Y.)

Engineers' Salaries and Professional Solidarity

To the Editor:

It has been said correctly that, if all the past work of engineers and scientists were wiped out today, the world would be back in barbarism tomorrow. It is interesting to ask why in view of this many of these men, who are the brains without which our civilization could not function, receive only financial compensation comparable with the wages of unskilled labor.

One who has studied the subject said that, when he found a badly paid engineer, invariably it was another engineer higher up who was holding down the subordinate's salary. An executive of a concern employing many engineers, with whom the writer talked on the subject, said that he never interfered in engineers' salaries, as they were decided by the manager of engineering who was an engineer with much experience in such matters. And some years ago the directors of the research organizations of two of the most important engineering concerns in the United States stated in addresses before one of the national engineering societies that it was inadvisable to pay high salaries to research engineers, as the money tended to distract their attention from their work.

The standard of ethics of the legal and medical professions frequently has been criticized. But we rarely hear of a member of either of these two professions assisting in beating down the fee of another member, when such fee is to be paid by a third party. In the recent American Society of Civil Engineers' discussion, wherein

some of the older members of the society endeavored to formulate a code of ethics which the junior members should follow, the writer suggested that, as he had never known a junior engineer to act except in accord with a high standard of ethics, whereas only too often he had seen older engineers sacrifice their standards, it was perhaps presumptuous for the older engineers to attempt to lecture the juniors on ethics.

If the salaries of engineers and scientists were increased to ten times their present amounts, it would be more in accord with the importance of their work; and, if this were done, the resultant added burden on the national economy would be less than one quarter of that resulting from the increase in the wages of labor since 1939. One of the important obstacles to be overcome before this can be accomplished is the attitude of the older members of the profession.

W. L. WATERS (F '13)

(Consulting engineer, Bury and Waters, New York, N. Y.)

NEW BOOKS • • •

"Bibliography of Industrial Engineering and Management Literature." The first section of this book is devoted to listing 1,208 books and bulletins on the general subject of industrial engineering and management. The second section constitutes references to 3,154 articles and papers on motion and time study and related subjects. The listing is alphabetical by authors; there is also a cross-reference listing by subjects. The subject index is divided into 47 main headings and 79 subheadings. By Ralph M. Barnes and Norma A. Englert. William C. Brown Company, 973 Main Street, Dubuque, Iowa, 1947, 135 pages, paper bound, $8^1/_2$ by 11 inches, $3.

"Electrons, Atoms, Molecules." Written to be comprehensible and interesting to both the layman and the scientist, this denial of the Bohr theory of solar-system type atoms is voiced in both mathematical and descriptive terms. According to his theory there is nothing to stop an electron in its progress toward the center of a hydrogen atom until it comes into actual contact with the positive nucleus, at which point the motion of the electron is stopped and the atom is in its most stable steady state. The author arrives at the conclusion that the radius of a hydrogen nucleus is negligible, that the radius of an electron is 1.83×10^{-3} and that atoms are at least ten thousand times smaller in diameter than predicted by Bohr. Mr. Crehore is a graduate of Yale and Cornell Universities and has done research work in electric railroads and range finders. He is the inventor of the Crehore synchrograph and the "dulex-diplex" system for sending through messages on lines in use by many way stations. For 20 years he has worked and studied in his private 3-story electrical laboratory in Yonkers, N. Y. By Doctor Albert Cushing Crehore. The Christopher Publishing House, 1140 Columbus Avenue, Boston, Mass., 1946, 133 pages, illustrated, $5^1/_2$ by $8^3/_4$ inches, $3.75.

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ELEMENTARY HEAT POWER. By H. L. Solberg, O. C. Cromer and A. R. Spalding. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1946. 480 pages, illustrated, $8^1/_2$ by $5^1/_2$ inches, cloth, $4.75. This new text aims to develop an understanding of the functions, principles of construction, and actual performance of heat-power machinery as a preliminary to the study of engineering thermodynamics. Consideration of matter and energy, fuels, and combustion are given first, followed by chapters on internal-combustion engines, fuel-burning equipment, and steam-generating and utilizing installations. Pumps, compressors, and other auxiliary equipment are dealt with, and there are also brief chapters on the gas turbine and mechanical refrigeration.

ANALYTICAL METHOD IN DYNAMICS. By H. O. Newboult. Clarendon Press, Oxford, England; Oxford University Press, New York, N. Y., 1946. 81 pages, illustrated, 9 by $5^1/_2$ inches, cloth, $2.50. This small book treats various topics in dynamics in ways that are intended to supplement the ones used in most textbooks. Special subjects dealt with are indicated by the chapter headings: two-dimensional dynamics; three-dimensional dynamics; applications of moving axes; the motion of a top; the motion of an inextensible flexible chain; and motion about a fixed point.

ENGINEERING TRIGONOMETRY. By E. M. J. Pease and G. P. Wadsworth. International Textbook Company, Scranton, Pa., 1946. 479 pages, illustrated, $8^3/_4$ by $5^1/_2$ inches, cloth, $2.75. Covering completely, though concisely, the basic principles of trigonometry, this text also includes such items as an adequate treatment of complex numbers, for electric network problems, and of the inversion process. Emphasis is placed on the direct use of principles rather than on the substitution of values in formulas. Special chapters are devoted to the construction and operation of slide rules, to approximate number computations, and to the applications of spherical trigonometry to problems in navigation.

FLUORESCENT LIGHTING. By A. D. S. Atkinson. Chemical Publishing Company, Brooklyn, N. Y., 1946. 144 pages, illustrated, $8^3/_4$ by $5^1/_2$ inches, cloth, $3.50. Full details of the construction and operation of all types of fluorescent lighting are given, and the application of fluorescent lamps in factories, public buildings, domestic interiors, and so forth is discussed and illustrated. The book is intended as a reference work for technical workers in the field as well as a text for electrical engineering students. The terminology differs from American usage in some respects, as the book is a facsimile of the second edition of a British book.

FREEHAND SKETCHING FOR ENGINEERS. By W. W. Turner. Ronald Press Company, New York, N. Y., 1946. 33 pages of text; plates A–J; 45 sheets of drawing problems; illustrated 11 by $8^1/_2$ inches, paper, $2.50. This publication consists of two general sections. The text section contains general suggestions for the student, freehand sketching procedure, and specific working instructions for individual sheets. The large number of plates are divided into a lettered series from *A* to *F* for study purposes, a series of drawing problems numbered 1 to 45, and nine practice sheets. The pages and plates are unbound but are fastened together and contained in a heavy envelope.

HEATING AND AIR CONDITIONING. By J. R. Allen, J. H. Walker and J. W. James. Sixth edition, McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1946. 667 pages, illustrated, $9^1/_4$ by 6 inches, cloth, $5. The new edition of this standard text has been revised as needed to bring it up to date. In addition to the revision of existing material, a new section on panel heating is included, and the principle of a reversed-cycle refrigeration system has been treated from a theoretical and practical viewpoint. A feature of the book is a detailed discussion of the design of an actual air-conditioning system. The book is suitable both for the engineering student and for home study.

INDUSTRIAL REPUBLIC. By P. W. Litchfield. Goodyear Tire and Rubber Company, Akron, Ohio, 1946. 201 pages, illustrated, $9^1/_4$ by 6 inches, cloth, $4. Stressing the importance of the individual and the necessity for effective co-operation between capital and labor, the author presents his material in four parts: part I is a reprint of an earlier publication in which the author examined our industrial economy, as of 1919, and suggested remedies for existing ills; parts II and III cover the respective periods as indicated, "Industry Under Industrial Assembly (1919–1936)" and "Industry Under National Unions (1936–1946)," as exemplified in the Goodyear plant; part IV seeks to define the spheres of responsibility of labor, capital and management in the attempt to realize a "democratic solution."

INDUSTRY AND SOCIETY. Edited by W. F. Whyte. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1946. 211 pages, diagrams, $8^1/_4$ by $5^1/_2$ inches, cloth, $2.50. The personnel problems of industry are viewed in terms of the structure of American society. The book explains some of the more serious maladjustments within the industrial system and presents a scheme of analysis for understanding and taking effective action in this field. Among the features of the book are the treatment of race relations, differences in individual motivation related to social status, analysis of status from the viewpoint of the executive, and a chapter on problems in a service industry.

MATHEMATICAL AIDS FOR ENGINEERS. By R. W. Dull. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1946. 346 pages, illustrated $8^1/_2$ by $5^1/_4$ inches, cloth, $4.50. This book gives engineers many basic mathematical tools essential for dealing with the higher mathematics involved in today's engineering developments. In addition to various chapters dealing with particular mathematical operations, there are chapters from the viewpoint of the types of motion involved, rotation, linear and harmonic motion, and so forth. The book is intended both for study and reference, and supplements the author's larger work, "Mathematics for Engineers."

PHOTOGRAPHY BY INFRARED. By W. Clark. Second edition. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1946. 472 pages, illustrated, $8^1/_2$ by $5^1/_2$ inches, cloth, $6. The underlying principles, the necessary equipment, and the characteristics of photographic materials are discussed first. Separate chapters then are devoted to photographic sensitizing of the infrared and sources of infrared radiation. The chapters dealing with the use of infrared in the examination of materials, medical work, criminological detection, fog penetration, and so forth, have been revised considerably to bring the book up to date, and new material on camouflage detection and forest survey has been added. Useful bibliographies accompany the various chapters.

PLASTICS HANDBOOK FOR PRODUCT ENGINEERS. Compiled and edited by J. Sasso. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1946. 468 pages, illustrated, 9 by $5^3/_4$ inches, cloth, $6. This handbook brings together practical and fundamental data on plastics and synthetic rubber for designers and engineers who want complete facts on the suitability of these materials in new product designs. The book contains specific information on all types of plastics and the properties of each; how to select the right type for a given application; processing, machining, and finishing plastic parts; and on design details such as tolerances, threads, fastening, and so forth. Valuable information is given on common faults, causes, and remedies in molded plastic parts. Synthetic rubbers also are covered, from both the chemical and engineering viewpoints.